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EDITORIAL

Let the Goose Live

AS WE recall it, the Wright brothers were not soldiers, nor was Simon Lake an admiral. We believe the tank and its tread sprang from the work of a man named Benjamin Holt. We doubt whether aluminum and magnesium alloys were developed in an arsenal, or whether smokeless powder originated in an ordnance department.

With occasional exceptions, the way of the military is not to create, but to confiscate the creations of the civilian. Apparently the soul of invention and discovery does not flourish in an environment of red tape and brass hats. After all, the military mind is trained in capture and demolition.

In a short war, no particular consideration need be given to the civilian capacity for creation. It will spring up again like the grass on the circus grounds. A *long* war is different. The military must have an unending supply of new materials, new mechanisms, new methods if they are to keep pace with the advances of the enemy. If the military are wise they will keep unclogged the spiritual springs whence flow inventions and discoveries. Otherwise they kill the goose that lays the golden eggs.

This is just as true on the food front as on the fighting fronts. It should be borne in mind by America before it gives too much rope to those who would simplify farm equipment manufacture by a ruthless regimentation. We suspect that victory in the battle of groceries will not be won by statistical strategists subtracting steel, but by the unsung inventors who find ways to turn green grass into protein concentrates, to plant and thin beets without help of hoe, to release manpower from field work for care of cow, sow, and hen.

Junkman, Spare That Tractor

A MEMBER of the Society that owns and publishes this journal, and an owner of some Dakota land, tells of trying to buy a tractor so that the man in charge might, despite shortage of help, put in a substantial acreage of flax and help meet the nation's need for linseed oil. The operator located a tractor to fit the need, a four-plow job, in serviceable condition. When new, over eight years ago, it sold for something under $1200. Despite its age, the price asked was $850, and it was in line with other similar transactions.

Certainly this is not the glamour of bright paint, nor the alleged anxiety of new money to be spent for new models. Rather it is economic law emphasizing the shortage of farm power in a size now needed to meet new quotas of certain crops in the extensive farming regions—a shortage aggravated by well-nigh complete suppression of manufacture of tractors in this size class. When tractors up to a decade old sell for two-thirds their original price, there can be no question of the need for power of their size and type, no better testimonial to their stamina and sustained usefulness.

The depression decade, with its unemployed labor, its scarcity of farm funds, and its thinly disguised bribing of farmers to curtail production, threw the man's-size tractor into temporary eclipse. All those conditions now are sharply reversed. We need more tractors big enough to get things done. Not only should we maintain all those now in service plus the few being built, but we should call back from the retired list all that can readily be reconditioned. A few pounds of metal in the form of bearings, valves, piston rings and expanders are all that usually will be needed to recommission a power plant twice as capable as a ton and a half of metal in a small tractor.

Because of their leadership in the policy of scrap-gathering programs, plus their educational work in the repair of farm machinery, all agricultural engineers should consider themselves trustees of this power reserve, and guard it from misguided zeal by junk collectors.

What Price Parity?

OUR intimate contact with farming makes us all too well aware of the economic handicaps under which it has operated. Our life work is to make better the financial, working, and living conditions of farm people. At the same time our instinct as engineers is to keep as far away as we can from politics. No wonder, then, that we are tempted to remain silent on the subject of farm price parity.

But we also know that by our work through the years we have substantially enhanced the productivity of labor by the farmer and his hired hands. For that reason and to that extent the use of 1914 or any such early year as a basis for computing parity is to argue from a false premise. Any scientific approach to farm price policy must include a correction factor which reflects the increased productivity of labor in agriculture.

It must also take into account the much greater part which farm machinery and other equipment play in the cost of farm products. And since equipment costs are proportional to the wages which go into them, the equipment component of farm prices must be prorated with industrial wages. For this reason, and for the further reason that farm labor costs tend to follow industrial wages, the soundest single consideration in a farm price policy is the relation to industrial wages.

In a peace economy it might be permissible to let city wages and farm prices rise and fall together. Under the inflationary pressures of a war economy, every effort should be made to hold them down together. This may seem like treason to those who see no further than pay per hour or price per bushel. It may be political suicide. It is all the more reason why engineers, who see further and who have no political aspirations, should speak firmly about wages and prices, the costs of war, and the heritage of debt we bequeath to our children.

Rough Ratios

IN recent years the manufacture of farm machinery has taken about two per cent of the nation's steel production.

Machinery for the production and harvesting of food took about half as much steel as was made into tin cans.

Total suppression of farm machinery manufacture, or a 50 per cent decrease in tin can usage, would release an amount of steel about equal to the rated tonnage of fifty aircraft carriers at 32,500 tons each.

A ton of material, made into a tractor and sent to Britain, saves each year seven to ten tons of lend-lease food and the shipping space it requires.

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Improving Efficiency of Farm Labor to Meet Wartime Demands

By E. W. Lehmann and H. P. Bateman

FELLOW A.S.A.E. MEMBER A.S.A.E.

IN undertaking to point out how the efficiency of farm labor, power, and machinery to meet wartime demands may be improved, it is desirable (1) to analyze briefly the situations, problems, and needs with which we are faced, and (2) to use this analysis as a basis for suggesting plans that we, as agricultural engineers, are responsible for carrying out in order to help meet the demands of the war emergency.

The increased production of food and fiber on farms is of first importance; however, the appeal made to the American farmer to produce more than ever before has been preceded by a period of controlled and reduced production. Now a program of education in production is necessary in order to achieve the goals that have been established. Such a program during the present emergency should give emphasis to (1) the conservation of natural and human resources, (2) the practice of thrift and frugality, and (3) the maintenance of a high state of morale.

The practices and plans that relate to the crop phases of this program will be given the most attention, since they are of primary interest to the power and machinery group of agricultural engineers. Much can be accomplished in saving labor through the use of special equipment in the production of livestock and livestock products; however, greater efficiency in the use of power and machinery for crop production will continue to make more labor hours available to devote to livestock and other secondary enterprises.

The improved efficiency of production in agriculture through the use of modern machines and power units has made it possible to secure an increased quantity of products with a decrease in the labor requirement. Much of the improvement has occurred since World War I. As a result we have produced beyond the capacity of our storage and processing facilities and at the same time have been able to release many workers to industry.

The effect of modern equipment in reducing the labor requirement is shown by farm management studies made at the University of Illinois. The records, secured from farm cooperators, cover a period of 25 years and measure the reduction in man-hours required for the principal crops. During that period the man-time requirement for the production of corn was reduced from 16.9 to 8.5 hr per acre, wheat from 14.2 to 3.7 hr per acre, and soybeans from 13.4 to 4.0 hr per acre. There were no tractors on the cooperators' farms at the start of the studies, but by 1936 all were equipped with tractors as the major source of power. Other equipment added during this period included combines, corn pickers, tractor-drawn corn planters, and tractor cultivators, none of which were in use at the start of the studies.

As a result of these changes since World War I, less labor is needed on farms for general crop production than ever before, and there has been some surplus labor on many farms in the grain producing areas. This available labor now will permit increased production of vegetables, milk, and pork products to help meet the increased war needs.

There are localized areas where the present labor supply is inadequate. The need for more labor is largely for dairy production, vegetable production, and seasonally for the fruit harvest.

Another labor problem to which we must give special attention, is the training of inexperienced and untrained workers to operate farm machines with the greatest efficiency and economy and with the least accident hazard. Machines will become more of a hazard as they wear and are in need of repair. In training

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Paper presented June 29, 1942, at the 35th annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis. A contribution of the Power and Machinery Division. Authors: Head and first assistant, respectively, agricultural engineering department, University of Illinois.

EDITOR'S NOTE: To provide a background for the suggestions and plans outlined in this paper, and to give more detailed information than the time allotted for its presentation would permit, the authors have prepared a 13-page supplement (mimeographed) which includes tables and figures prepared as part of an analysis of the present farm labor, power, and machinery situation. Copies of this supplement are available on request.

inexperienced farm workers, the accident hazards should be stressed so that accidents will not happen to the operator and to the equipment. Safety instruction should likewise include a caution as to the danger of handling horses. A summary of farm accidents in Illinois in 1941, of which there were 3,598, indicates the importance of this, since there were 458 horse accidents resulting in 37 deaths, and 362 tractor accidents resulting in 20 deaths. A summary of accidents during the past five years shows that accidents resulting from the use of machines cause varying amounts of labor time lost. Much is being accomplished through the efforts of vocational agriculture teachers, county agents, and local implement dealers, in training boys in the safe and efficient handling of machinery and power units.

The labor situation is destined to become more serious the longer the war lasts. It is necessary that plans be worked out and extensive training programs promoted to help relieve the labor shortage.

An analysis indicates that the present power situation is favorable. Due to the large increase in the number of tractors and the improved efficiency of these tractors, there is more primary horsepower available on farms than ever before. Its distribution is such that a large percentage of the productive area has tractor power available. For example, approximately 52 per cent of the farms in Illinois are equipped with tractors and about 80 per cent of the crop area is included in these farms. The tractor power available would be adequate to farm the other 20 per cent of the crop area of the state, if it were possible to make the proper farm adjustments.

However, we must not overlook the serious effects that may result from the limitations on tractor replacement in the future. Already more than 42 per cent of the tractors on Illinois farms and more than 51 per cent of the tractors in the United States are more than seven years old. The maintenance of farm power equipment is, therefore, of ever-increasing importance. The agricultural engineers in the colleges and those connected with the tractor, implement, and fuel companies are faced with the responsibility of keeping the tractors running. Another problem that may become critical in some areas is that of supplying sufficient fuel to the farmer. In any case there is a need to keep the tractors properly adjusted and in good repair, to keep the amount of fuel consumed at a minimum, and thus conserve one of our important natural resources.

Farm managers are of the opinion that the machinery situation is better than ever before. Many new machines have been purchased in recent years for use with tractor power; however, there are machine shortages in some areas. For example, there are communities where the acreage of soybeans grown will be greater than the capacity of the combines to harvest them. Farmers in Illinois are being cautioned to be sure the combine they are depending on has adequate capacity and will be available to harvest their soybeans. In Illinois we have cooperated with the state war board to determine those areas which may prove to be critical ones for the farmer so that the condition may be remedied before it becomes serious.

The present labor, power, and machinery situation can best be summarized by saying it seems evident that in some areas there will be a shortage of labor, in others a shortage of power, and in still others a shortage of machines.

A real problem that is nationwide and deserves a great deal of study is that of ineffective use of labor because of small farms, small fields, rough topography, inadequate machines; or it may be that the entire program of production has been developed with a plentiful supply of cheap labor which is not now available.

The importance of this group of low-income farmers is shown in the statements made by Hammer and Buck in the April issue of the U.S.D.A. "Land Policy Review": "These 2,717,000 under-employed, low-income (below $1,000 per year) farmers constitute about 56 per cent of the bona-fide farmers of the nation. . . . . . When it is realized that more than half of the nation's productive agricultural man power is located on these 2,717,000 farms, and that (1) the larger commercial farmers are already producing at capacity or near capacity by hiring labor, by already being more completely mechanized, and by already utilizing the most efficient methods; (2) as farm labor becomes scarcer, these commercial farmers may actually decrease their output of farm products — it becomes immediately obvious that the resources of these under-employed farm families must be mobilized immediately if we are to produce the food necessary to win the war."

In this discussion of plans directed toward improvements to be brought about in crop production, the low-income farmer should be considered. The authors just quoted felt that this group of farmers would contribute most in the secondary production enterprises of livestock, vegetables, and a small amount of field crops.

To meet wartime needs best, a goal to strive for should be to give, first, consideration to plans to make the most effective use of existing machines and power units with labor available, and, second, to provide additional machines and power units where the need becomes critical. In making these plans we should incorporate those farm management practices which will be needed to make the program effective, and specifically we should incorporate suggestions to improve the efficiency and economy of farm labor, power, and machinery use under wartime conditions. The production may have to be accomplished through the sacrifice of some soil and other resources, and through lowered standards. However, serious mistakes that were made during the last war of exploiting highly erosive soils should be avoided during World War II, if possible.

Five activities are essential to carry out this coordinated program to make the most effective use of labor, machines, and power, and agricultural engineers can participate and assume a responsibility in furthering them. They are as follows:

1 To train machine operators and repairmen
2 To plan for the extended use of existing machines locally and in areas of machine shortages, along with the best placement of new machines
3 To determine methods and promote plans to improve tractor efficiency and economy, and to extend years of service
4 To develop and crystallize an engineering approach to the selection and use of farm power and machinery units
5 To sponsor an accident and fire prevention program.

This list of activities to meet the need of the present situation are submitted for discussion. It seems evident that details must be worked out for each state and area.

1 *Training of Operators and Repairmen.* We do not know nor can we determine accurately just how much trouble farmers will experience as a result of the experienced men and boys leaving the farm, and the closing of repair shops that in the past were responsible for keeping the equipment on farms operating effectively. It is now our job to assist in training the people who are left to operate and repair this equipment. This will have to be done quickly in as effective a manner as possible, and training courses will have to be repeated frequently due to the continual change of operators and repairmen.

One of the more important factors in keeping farm machinery at the highest possible state of operating efficiency will be the proper adjustment of the equipment to meet the varying conditions under which it works. Agricultural engineers are in position to render important service toward that end

The most effective means of reaching the people quickly is to teach leaders who in turn will teach the people in each community. At the University of Illinois we have held short intensive courses for high school teachers. In some instances similar schools are held by manufacturers for their dealers. In holding these schools it is well to consider the need of specific areas, and those areas showing the most need should be served first and the school adapted to the need using all local agencies and facilities that can be used effectively.

2 *Extending the Use of Machines.* Many machines now on farms are not used as many hours during the year as they could effectively be used. This extra available use which the duty of the machine and time would permit could take care of the machine and labor shortage in some areas. To be able to get all the crops harvested some men who own harvesting machines can and will do more custom work as a patriotic duty, even though their personal inclination is to use the machine only for harvesting the crops on their own farms, since a new one will not be readily available. In a recent circular prepared by the Department of Agricultural Engineering, University of Illinois, a table showing the number of acres of soybeans that can be harvested during a season for various sizes of combines and different lengths of harvesting periods, is provided to help farmers in making plans to get the crop harvested on time. There is no doubt a need for similar material relating to other machines.

Programs have also been sponsored in the state to make obsolete or unused machinery on one farm available for use on another farm where there is a need. For example, there are good horse-drawn cultivators on some farms that have not been disposed of since a tractor cultivator was purchased. These cultivators are useful on farms where horses are still being used.

Already new machines are being sent to areas in proportion to the need that exists. This practice will be followed more in the future as the need for various machines becomes critical in given areas. Studies are essential to determine the areas of greatest need so that machines can be equitably placed and repair facilities provided.

To insure the success of such plans, considerable thought and cooperative effort will be needed to make them workable. At times like the present, the interest and leadership of individuals can be maintained on the basis of the patriotic duty of the people, and results will be secured that would be considered fantastic in peacetime.

3 *Improving Tractor Efficiency and Economy.* The designing and research engineers and the manufacturers have done much to improve the tractor for the farmer by making it better adapted to his uses, by improving its efficiency in the use of fuel, by increasing the percentage of belt power, and by improving its quality to increase its life. With the present limitation on tractor manufacture, we cannot expect changes in design which will further improve tractors to meet the present situation. During the period of the war, effort must of necessity be devoted to the manufacture of machines already designed and proven practical.

Our immediate problem then is not one of improving tractor design but one of operating existing tractors and machines at the greatest efficiency and economy for which they are built to operate. Farmers need to be informed of the importance of operating tractors at or near rated load. The use of machines of the correct size and the use of combinations of machines that will make a full load for the tractor is important.

The problem of making more use of the tractor each year deserves attention, because tractors are normally used a relatively small number of the available hours per year. The results of a study in 1938 of 12 tractors, used by a group of better than average farmers in Champaign County, Illinois, on farms of various sizes, show that the tractors were used from 400 to 800 hr, whereas there were 1,470 daylight hours suitable for field work during that year from March 21 to November 22. That tractors may be used more hours per year is indicated further by the fact that one tractor, on which a detailed record was kept, was used on an average of 970 hr annually by a Champaign County farmer for the past 14 years. During the single season of 1938, this tractor was operated 1,374 hr. By using the tractor more hours a lower cost per hour of operation results and the extra hours of use takes care of some of the labor shortage. On many farms more effective use can be made of tractors in the care of livestock and in doing other jobs about the farmstead.

More emphasis is needed on the importance and methods of keeping the tractor in correct adjustment and in good repair so that its operating economy and efficiency is more nearly that for which it was designed. The Champaign County study indicated further that many of the tractors were being operated in a condition that resulted in poor fuel economy and poor power performance. The effect of poor fuel economy increases the cost for all operating loads of the tractor. This study included tests of the tractors as the farmers operated them. These tests indicated that individual tractors were being operated with efficiencies of 50, 60, and 65 per cent of the maximum for which they were designed, with an average of 80 per cent for all of the 25 tests. By proper adjustment and repairs the efficiency of these tractors was increased from 20 to 50 per cent in seven cases and an average increase of 12 per cent for all the tests. While individual tractors developed only 60, 70, and 75 per cent of their maximum power, the average was 90 per cent. Complete records for the year indicate that some of the tractors are operated a large number of hours at fuel consumption rates that are excessive, due to improper adjustment of the fuel system rather than overloading the tractor. Results of tests of two tractors of the same make and model, operating 475 and 525 hr each and pulling similar sizes of implements, showed an average fuel consumption for the year of one-half gallon more per hour for one of the tractors than for the other.

The improvement of the performance of the tractors tested was brought about in many cases by minor yet important adjustments and repairs. They included the adjust-

ment of the carburetor, the adjustment of the governor, cleaning out a clogged air cleaner, removing dirt from between the radiator fins, and making repairs of magnetos and grinding valves. In our effort to conserve fuel such simple adjustments, if made, generally would save literally millions of dollars for the farmers and many millions of gallons of fuel for the war effort. Such adjustments should be stressed in our educational program for tractor operators and repairmen.

4 *An Engineering Approach to Selection and Effective Use of Power and Machinery Units.* During the present emergency, many farmers must accomplish tasks with power units and machines that under normal conditions would not be achieved. To attain a maximum result, economically and efficiently, facts relating to operating characteristics of power units and machines must be known.

An understanding and knowledge of the duty of the machine, the relation of proper loading of power units to efficiency and fuel economy, and the need for regular inspection and maintenance is essential to a sound engineering approach to the farm production problem. These engineering facts relating to power and machinery units, coupled with an analysis of the needs of the job, constitute an engineering approach to the farmers' problem. The problem at hand may be seedbed preparation, planting on the contour, cultivating for weed control, or harvesting. Agronomic and management factors relating to requirements of the job at hand must be known to attain best results.

The change from horse farming to mechanized farming has been accomplished over a limited number of years and has resulted in many traditional practices being followed by individual farmers. Breaking away from tradition, doing things differently, and the introduction of new techniques and machines are contributions of the engineer in our modern technological development.

To save labor and power, consideration should be given to changing some of the common farm practices, such as preparing seedbed by disking instead of plowing and disking, drilling corn on the contour instead of checking it, reducing the number of cultivations, and quitting the grinding of ordinary roughages. These are only a few practices that might be changed or eliminated as a means of saving labor and energy.

5 *An Accident and Fire Prevention Program.* Loss of life and reduction of labor efficiency due to accidents when faced with the need of producing a maximum of agricultural products, becomes a matter of great importance, particularly when there is a shortage of trained machine operators and a shortage of certain machines. Loss by fire due to accidents or otherwise is also important.

The importance of the problem to farmers is shown by the following data: There were approximately 4,500 deaths from farm work accidents in the United States in 1941. The loss-time accidents were probably 15 times this number. In Illinois during 1941, there were 246 deaths resulting from 3,600 farm work accidents. This is only a small fraction of the total number of accidents and deaths of members of farm families when we consider automobile accidents and miscellaneous accidents in the home.

The following are some of the reasons why a program of safety should be emphasized at this time:

1 Adequate and efficient manpower is essential to make our total war effort effective
2 The loss of labor and time due to accidents will handicap our national war effort
3 It is the patriotic duty of every individual to avoid waste by preventing losses from accidents
4 With a shortage of labor the demand for increased production will necessitate longer working hours and the use of inexperienced operators
5 It is estimated that 85 per cent of all accidents are due to human failure and something can be done about it
6 Individuals involved in accidents may be made to feel a moral and legal responsibility
7 The shortage of new machines and available repairs will increase the machine hazard
8 Accident prevention should be a part of county agricultural planning.

Because of the need and importance of the problem at this time, a general project on rural fire and accident prevention is proposed. To meet this need in Illinois such a project has been organized with the following objectives:

1 Develop accident consciousness in farm families
2 Assist individual farm families in recognizing and eliminating accident hazards
3 Assist in training programs in accident prevention and control and in first aid to the injured
4 Determine the types and causes of accidents in different areas of the state, using this information in so far as is possible to determine the type of training necessary for local leaders.

Plans to Carry Out the Program. The responsibility of those who have a part in planning the programs is greater under the present critical circumstances. The job is not one for any particular group, but one to which many agencies can contribute as a direct responsibility and a definite patriotic duty. When our efforts are directed toward winning the war, the appeal takes on a different significance. The attitude of farm people at this time will make them receptive to a sound program that gives them an opportunity in the war effort. Town people no longer take for granted the idea that food will always be available in abundance; they want a part in making this possible. The victory gardens in our cities have become popular, and the schools, the churches, the civic clubs, and the professional organizations have become concerned and feel they have a definite responsibility along with the farmers who normally assume responsibility for the production of food. In some communities, town and city people have organized to schedule their time so they can help farmers when a rush period arises.

The state and county war boards have an important responsibility in locating critical areas of need that have developed as a result of the war. The agricultural engineers are in a position to assist the war boards in securing and analyzing the information that should be available in planning programs to meet local situations. A close cooperative relationship is therefore essential. With the director of the agricultural extension service, a member of the state war board, and the county farm adviser (county agent), a member of the county war board, this is possible.

The national plan of reaching each individual farmer by the agricultural extension service through a special county organization will be a large factor in making a program effective. This can be done through the use of leaflets, movies, radio, news items, posters, charts, and direct community contacts with farmers through the dealers, vocational agriculture teachers, farm advisers, and other agencies through which the program can be promoted. The college and extension agricultural engineers, in cooperation with implement, tractor, and fuel company engineers, are in a position to direct the educational phases of this program to secure the most effective results.

Irrigation Water Supply System Capacities

By C. V. Givan

ONE of the first steps in the design of an irrigation system is to determine the rate of discharge from the water-supply system which is required to satisfy the soil-moisture needs of the growing plants. By accounting for additions to and subtractions from the soil-moisture supply in each part of the irrigated area throughout the growing season, it is possible to determine whether or not a sufficient supply of soil moisture for a particular irrigated planting can be maintained when water is applied by some systematic method from supply sources with various rates of discharge. A graphical method devised to make these determinations is explained by referring to diagrams used to study the irrigation of a mature prune orchard which is growing where soil and climate are similar to those of Davis, Calif.

The first diagram (Fig. 1) was drawn to find out if a uniform rate of discharge from the supply system of 1.0 cfs for each 80 acres irrigated would be sufficient to meet all soil-moisture losses from the selected orchard. In this example the customary practice is followed of applying uniform depths of water successively to each of a series of checks or basins which subdivide the irrigated land. The second diagram (Fig. 2) shows results which can be obtained when it is permissible to vary the depth of water applied during any particular irrigation. In this example, the rate of discharge from the supply system, 1.0 cfs for each 96 acres irrigated, equals the average rate at which soil moisture is lost during the month of greatest loss.

Article prepared especially for AGRICULTURAL ENGINEERING. Author: Assistant professor of irrigation, University of California.

From experiments performed at Davis, Calif., it has been concluded[1]* that the application of water to a prune orchard shortly before the moisture content of the top six feet of soil is reduced to the permanent wilting percentage constitutes good irrigation practice. The permanent wilting percentage[2] is the moisture content below which the trees cannot readily obtain water. In other words, if none of the trees are to wilt, each part of the planted area should be irrigated before its supply of readily available soil moisture is exhausted which may occur several times during the growing season.

In Figs. 1 and 2, the rates at which moisture was lost from the top six feet of soil in a mature prune orchard at Davis are represented by the slopes of line *A*. Water was readily available to all trees during the growing season. Moisture contributions from rainfall between the time in March when transpiration began and the end of October are not considered important. Measurements of soil-moisture losses were made from soil samples taken from each foot of soil depth. Average monthly losses are shown in Table 1.

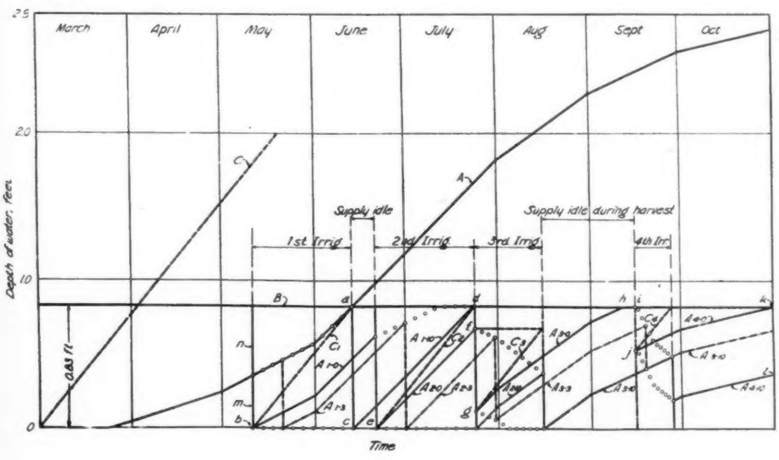
TABLE 1. AVERAGE LOSS OF SOIL MOISTURE FROM TOP SIX FEET OF SOIL IN A MATURE PRUNE ORCHARD AT DAVIS

Month	Depth of water, ft.	Month	Depth of water, ft.
March	0.04	July	.64
April	.21	August	.45
May	.33	September	.28
June	.60	October	.15
		Total	2.70

The maximum rate of soil-moisture loss of 0.64 ft depth of water during July is equivalent to a continuous rate of loss of 1.0 cfs from 96 acres of planted area.

The trees are growing on Yolo loam soil. After it has been wet, the top six feet of this soil holds 0.83 ft depth of readily available moisture. This depth of water, represented by line *B* drawn parallel to the time axis, has been supplied by winter rainfall before the beginning of the growing season. Line *B* intersects curve *A* at point

*Superscript numbers refer to the references appended to this article.



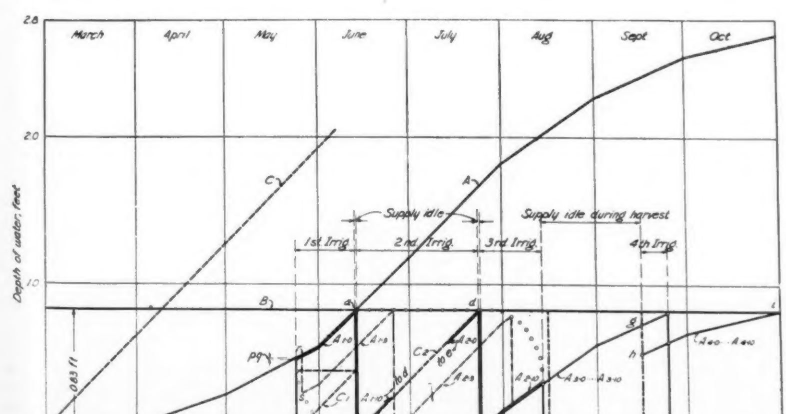


Fig. 1 (Above) Uniform irrigation applications • Fig. 2 (Below) Combined variable and uniform applications

a on June 13th. Unless irrigated previously, all trees would exhaust the soil-moisture supply in the top six feet of soil on this day.

Uniform Applications. In this example, it is assumed that a continuous rate of discharge equivalent to 1.0 cfs for each 80 acres of irrigated area is available upon demand. The inclination of C remains unchanged when the ratio of discharge of the supply to the area irrigated is constant. The projection on any line parallel to the time axis of the part of C which extends from the origin to C's intersection with B is 33.5 days, the time required to apply 0.83 ft depth of water to an area of 80 acres when 1.0 cfs is supplied continuously.

Water can be applied at any time except within the harvest period between August 15 and September 15. During any particular irrigation, the customary practice of applying a uniform depth of water to all parts of the orchard is followed.

If a uniform depth of 0.83 ft of water is to be applied during the first irrigation, the date for starting this irrigation is established by the intersection of the time axis at b on May 11 by line C_1 which is drawn parallel to C through point a. The application of 0.83 ft depth of water on this date replaces the amount of soil moisture m which has been removed from storage, and displaces the depth of water n from the top six feet of soil, because 6 ft depth of this soil cannot hold more than 0.83 ft depth of water between its field capacity and its permanent wilting percentage.

The lines $A_{1\cdot0}$ and $A_{1\cdot10}$ drawn parallel to A through points b and c, respectively, indicate the amounts of soil moisture which remain in storage in the first and last parts of the field after the first irrigation. The small circles are located at the ends of similar lines (not shown) which indicate the amounts of soil moisture in storage at the beginning and end of irrigation of intermediate positions in the irrigated field. The dashed-line $A_{1\cdot3}$ is also parallel to A and represents the soil moisture in storage at the end of the first three-tenths part of the area after the first irrigation has been applied.

The last tree irrigated during the first irrigation would exhaust the readily available soil moisture again on July 23 when line $A_{1\cdot10}$ intersects B at d. If a second uniform irrigation of 0.83 ft depth is applied, it will begin on June 21 when line C_2 drawn parallel to C through d intersects the time axis at e. It will be noticed that the fraction of water applied during the second irrigation which percolates below the sixth foot of soil is smaller than the fraction which seeps away during the first irrigation. Water reaches the last third of the area at almost the same time as the stored supply is exhausted.

The third irrigation cannot continue beyond August 15 when preparation of the ground surface for the prune harvest begins. From the end of the second irrigation on July 23 until August 15, a uniform depth of 0.54 ft of water is the greatest amount of water which can be supplied by continuous operation of the supply system. Consequently, line C_3 is drawn parallel to C so that its projection of 0.54 ft, depth fg, begins at f, the point reached by $A_{2\cdot0}$ on July 23. When $A_{3\cdot0}$ is extended from g parallel to A, it intersects B on September 11 at point h. Between this date and September 15, point i, when the last irrigation begins, moisture is not readily available within the top six feet of soil at all times to trees within about the first tenth of the irrigated area.

The last irrigation provides water needed until the end of October after which the moisture loss is low and less than is contributed usually by rainfall. The segment of $A_{4\cdot0}$ drawn parallel to A between September 15 and October 30 is projected from k where B meets the October 30 date line. Its projection ij, equal to 0.30 ft, is the depth of water which is equal to the moisture lost between September 15 and October 30. If this depth of water is applied uniformly throughout the orchard during the fourth irrigation, the moisture in storage on October 30 will range from zero in the first part of the area to 0.46 ft depth, Kl, in the last part irrigated. The average depth which remains in storage is about 0.22 ft. An examination of the diagram shows that sufficient moisture is in storage after the third irrigation in the last half of the orchard to supply its demand until October 30; consequently, irrigation could have been stopped on September 26 unless there was need to wet soil within the last half of the orchard in order to produce a cover crop.

Variable Applications. When it is feasible to apply variable depths of water to different parts of an area during a particular irrigation, it is possible to irrigate so that there will be very little deficiency of soil moisture or downward percolation of water below the root zone. A sample diagram is shown in Fig. 2 where both variable and uniform applications are made and where the rate of discharge is equal to the maximum monthly soil-moisture loss. With applications varied in a way which can hardly be considered practicable, it was found that the same prune orchard used in the first example could be irrigated without deficiency and with a volume of water equal to the total soil moisture lost after subtraction of moisture held in storage from rainfall at the beginning of the season.

Fig. 2 was constructed as follows: Lines A and B are identical with those in Fig. 1. The supply line C is drawn parallel to the segment of A which indicates the rate of loss of moisture during July, the month of greatest loss. This loss rate is equal to 1.0 cfs from each 96 acres irrigated.

It has been found that variable applications of water ranging from almost zero depth at the beginning to 0.83 ft depth at the end of the first irrigation, could be applied at times which would permit a uniform application of 0.83 ft depth during the second irrigations without deficiency or downward percolation of the soil moisture. Application of 0.83 ft depth of water to the last tree during the first irrigation is shown by line ac. Line $A_{1\cdot10}$ indicates the rate at which moisture available to this tree is lost from storage. It is extended parallel to A from c to d, which marks the end of the second irrigation. Line C_2 is drawn parallel to C through d. Its intersection with the zero depth line at e fixes the time of the beginning of the second irrigation. The projection of de on B is divided into ten parts which indicate when water is applied to the beginning and end of each tenth part of the area during the second irrigation. As shown by $A_{1\cdot3}$, lines parallel to A are extended from these division points. For instance, at any time during the first irrigation, application of a depth of water rs must be applied to the end of the third tenth of the area if $A_{1\cdot3}$ is to have the position shown. All of the lines $A_{1\cdot0}$ . . . . . $A_{1\cdot10}$ are parallel to A and intersect the straight line B at equidistant intervals. The depths of water applied to each successive part of the area during the first irrigation increase in proportion almost directly from the small depth pq to depth ac. Practically, the average depth of water applied during the first irrigation may be calculated as follows:

$$D_1 = \frac{pq + ac}{2} = \frac{.01 + .83}{2} = 0.42 \text{ ft}$$

The first irrigation extends over 20.3 days, because it takes this time for a continuous flow of 1.0 cfs to cover 96 acres with an average depth of 0.42 ft of water.

The third irrigation is of variable depth like the first. The greatest depth of water, however, is applied to the first part of the orchard, i.e., the part which received the least depth during the first irrigation. This reversal of the order in which the variable depths of water are applied, equalizes the moisture content in all parts of the orchard as shown by line $A_{3\cdot 0}$ . . . . . $A_{3\cdot 10}$. This irrigation is completed before August 15 when harvest begins, and leaves sufficient moisture in the top six feet of soil to supply some demands beyond September 15.

A uniform depth of 0.2 ft of water *gh* is applied during the fourth irrigation which starts on September 16. Point *g* marks the intersection of the September 15 date line and the part of $A_{3\cdot 0}$ . . . . . $A_{3\cdot 10}$ which indicates the soil-moisture content after the third irrigation. Point *h* is located on the same date line by its intersection with $A_{4\cdot 0}$ . . . . . $A_{4\cdot 10}$, which is drawn parallel to *A* through *i* where line *B* intercepts the October 30 date line.

An experienced irrigator will recognize that it is not practicable to distribute small depths of water nor to vary them exactly as described in the explanation of Fig. 2. However, where water is expensive or limited in volume, it is likely that some advantage could be gained by applying a minimum practicable depth to the first and last parts irrigated during the first and third irrigations, respectively. Also, when the rate of discharge of the pump or gravity supply equals the rate at which moisture is lost during the month of greatest use, it would be very difficult if not impossible to keep moisture available in all parts of this orchard if the usual practice of applying uniform depths throughout the orchard during a particular irrigation is followed.

Results. Studies like those shown in Fig. 1 were made when the rates of discharge available from the supply were equivalent to 1.0 cfs for each 60 and 40 acres, respectively. An inventory of the disposition of the water stored from rainfall and applied by irrigation is shown in Table 2. The ratio of the rate of discharge of the supply to the area irrigated in acres has been called the "supply-demand ratio", although it might be more logical to call it the "area-discharge velocity" since this ratio is a rate of discharge divided by an area.

It is interesting to note the effect of changes in the supply-demand ratio upon the total depth of water applied during the irrigation season when all applications are of uniform depth. Since 0.83 ft depth of moisture is available from rainfall storage at the beginning of the growing season, an additional supply of 1.87 ft would satisfy all soil-moisture losses from the top six feet of soil if it were available in all parts of the orchard when it was needed. The total application depths shown in Table 2, however, are 2.50, 2.38, and 2.22 ft when the supply-demand ratios are 1/80, 1/60, and 1/40, respectively. The differences of 0.63, 0.51, and 0.35 ft depth between the water supplied and the moisture losses measured by soil sampling, do not include any conveyance losses which will also tend to decrease as the supply-demand ratio increases. When the supply of water is limited, the possibility of reducing the total volume of water applied during the irrigation season by increasing the capacity of the supply system should not be overlooked.

The disposition of the differences listed in Table 2 is of interest to the hydrologist. When the winter rainfall is greater than needed to wet the top six feet of soil to its field capacity[2] and to supply the moisture requirements of vegetation such as cover crops which grow when the trees are dormant, the entire difference may percolate below the root zone and eventually reach water-bearing formations. If this rainfall plus the soil moisture in storage at the end of the growing season is less than the field capacity of the top six feet of soil, all or a portion of this fraction held in storage will be available to the trees during the following year unless the rainfall is so small that all of the soil moisture is removed by transpiration of winter vegetation or by evaporation.

TABLE 2. DISPOSITION OF WATER APPLIED TO PRUNE ORCHARD AND OPERATION TIMES OF SUPPLY SYSTEM

Depths of water applied, stored, or lost, ft	Supply-demand ratios, cfs per acre $\frac{1}{80}$	$\frac{1}{60}$	$\frac{1}{40}$	$\frac{1}{96}$
Irrigation applications				
1st	0.83	0.83	0.83	0.42*
2nd	.83	.83	.83	.83
3rd	.54	.42	.26	.42*
4th	.30	.30	.30	.20
Total applications	2.50	2.38	2.22	1.87
Water stored in top six feet of soil at beginning of irrigation season	0.83	0.83	0.83	0.83
Storage plus applications	3.33	3.21	3.05	2.70
Water lost from top six feet of soil during growing season	2.70	2.70	2.70	2.70
Difference	0.63	0.51	0.35	0
Water in storage in top six feet of soil at end of growing season	0.22	0.22	0.18	0
Water which percolated below top six feet during the growing season	0.41	0.29	0.17	0
Seasonal irrigation time, hr	2440	1727	1075	2170

*All applications excepting these are uniform in depth through the irrigated area.

The effect of changes in the supply-demand ratio upon the seasonal operation time of the supply system is shown by the last line in Table 2. Under conditions existing in the sample orchard used in this study, the practical difficulty of extending operation beyond a time interval which approaches, 2,000 hr should be apparent. Many prune orchards of the Sacramento Valley of California, are not provided with available soil moisture throughout the growing season, although many orchardists try to prevent any of their trees from wilting even during harvest. Their irrigation problem is complicated also by variations in the moisture-holding characteristics of the soil from place to place. The result is that most orchardists have good reason for their desire to have not less, and sometimes even more, than 1.0 cfs of supply for each 60 acres irrigated even though the cost of a unit volume of water usually increases with the supply-demand ratio.

This graphical method of accounting for changes in the soil-moisture regimen has not been applied to other problems where other rates of loss and soil-moisture capacity are assumed to exist. However, there seems to be no reason why the method cannot be used to solve even more complicated problems of this type. In fact, the method might be useful in determining the rates at which any material should be supplied from one or more sources for storage in a series of places where it is required that stored material be available at all times during which it is to be withdrawn from each storage place at known rates of withdrawal.

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Terrace Construction by Plowing

By Dale E. Springer

CONSTRUCTION of terraces by plowing was studied on the Earl Welch farm near Bethany, Missouri, in the fall of 1939 and the spring of 1940. These studies were carried out on Shelby soil, and since that time terraces have been constructed successfully by this method on several other soil types under varying moisture conditions.

This method consists of plowing a backfurrow for the terrace ridge and a deadfurrow for the terrace channel. Each farmer uses the procedure or sequence of rounds that suits the slope of the land and soil and moisture conditions. A farm tractor with a two or three-bottom moldboard plow has been used for most of this construction. Three or four repeated plowings of the loose soil can be made to heighten the ridge and to increase the depth and width of the channel. A plow-built terrace will have from 5 to 10 sq ft in the terrace channel cross section and a terrace ridge 12 to 15 in high in about 15 rounds.

The efficiency of this method of terracing depends to some extent on the moisture content of the soil. Best results have been secured by building the terrace when the ground is too wet for regular field plowing, because wet soil packs and can be replowed somewhat easier. A plow usually does not scour well in replowed soil but moves it nevertheless. After a rain that settles the terrace ridge, a few more rounds by this same method will add height to the ridge and depth to the channel. Subsequent plowings of the field after crop harvest should be made parallel to the terrace to maintain it. By proper plowing, the cross section of the terrace can be improved each year and adapted to farm implements.

In the past many engineers have built terraces large enough to be effective after settlement for three or four years without any maintenance. As a result many farmers either neglected maintaining their terraces or forgot them entirely. These terraces were expensive to build. The soil that goes into the top of the ridge is the most expensive to move because it is moved up on a loose ridge, or the ridge is packed by additional trips. By the plow method of construction, the terrace base is built and allowed to settle. Later the top of the ridge is built more efficiently over this settled soil. It is recognized that the new terrace built by plowing usually is not large enough to hold for more than three to six months. Additional plowing should be done as soon as possible after the ridge is settled to avoid overtopping after heavy rains.

Some of the advantages of plow-constructed terraces are:

1 The equipment required is available on most average-sized farms in the corn belt.

2 The tractor and plow are (Continued on page 286)

Article prepared especially for AGRICULTURAL ENGINEERING. Author: Assistant agricultural engineer, Montgomery County Soil Conservation District, Red Oak, Iowa.

Upper left: In this view terrace construction has been started by plowing the first furrows approximately 5 ft from each side of the stake line • Upper right: This is the second round which the plow made inside the area bounded by the soil thrown over from the first round. The following round will be made by plowing as deeply as possible to pick up the soil thrown over from the second round as well as some of the unplowed soil. Thus a backfurrow is formed from a large quantity of soil • Lower left: This view shows that the terrace ridge is increased by plowing from the upper side. On the return trip the strip above the channel is plowed uphill to increase the channel capacity. In this way more of the field can be plowed while constructing the terrace • Lower right: The terrace has a ridge 15 in above the channel and a channel cross section of 11 sq ft. Howard Jackson, standing in front of his tractor and plow, built this 400 ft of terrace in 1 hr and 15 min

Gearing Farm Machinery to the War Effort

By F. A. Wirt
FELLOW A.S.A.E.

FOOD is essential to the well-being of a people at peace and to the success of a nation at war. There has been plenty of food for so long in the United States that the American people have forgotten that abundant food supplies are the exception and not the rule.

The responsibility of agricultural engineers under present conditions is threefold: (1) To assist in bringing about the best possible use of such new machines as the manufacturers may be permitted to build, (2) to promote efficient use of old machines through proper servicing and stocking of repair parts by implement dealers, and (3) to make their knowledge known to men in authority on all matters pertaining to the application of engineering in agriculture.

This responsibility is all the greater today because less than 25 per cent of the population is on the farm, as compared with approximately 90 per cent one hundred years ago; and consequently many in authority do not know what is required to produce food in sufficient quantity. Many important decisions are not in the best interests of either agriculture or the nation simply because they are made by men unfamiliar with the influence of farm machinery on agriculture, and on the nation.

Three times since the shift from hand to machine methods in this country American farmers have been asked to produce food enough for themselves, for civilians in general, for the armed forces, and for other countries. By referring to these past experiences, we can better understand the relationship of farm machinery to food in wartime.

Few realize the important part played by farm machines during the war between the states. Farm boys and hired help went to factories and to the armed forces. Farmers were short-handed, but their responsibility in growing food was greater than they were ever to know. During 1861, 1862, and 1863, Great Britain experienced a drought of serious proportions, and during one of those years there was drought over all Europe. But food was available because of American farm machinery and in spite of a labor shortage on American farms. Some students of history are convinced that food for Great Britain was a definite factor in determining the outcome of the war between the states, for Great Britain, needing cotton as badly as she did, needed grain more.

On July 4, 1863, this significant statement appeared in the "Scientific American": "Manual labor was so scarce last August that but for the horse rakes, mowers, and reaping machines, one-half the crops would have been left standing in the field. Farming is comparatively child's play to what it was twenty years ago, before mowing, reaping, and other agricultural machines were employed." Then farm machinery manufacturers were not restricted in the building of necessary farm machinery, the production of which steadily increased. Food was recognized as a munition of war.

When war broke out in Europe in 1914, the American farmer, for the second time, had greatly improved equipment with which to produce a surplus to feed himself and others, and again the production of farm machinery increased during the war. In spite of a serious shortage of labor the farmers achieved a tremendous output of needed foodstuffs.

Materials were scarce and difficult to get in 1917 and 1918, but the government recognized the need for farm machinery, although there probably would have been a reduction in 1919 as compared with 1918 if the war had continued. It is also significant that the annual production of farm equipment was substantially higher at the end of the war than in 1917 or in 1914, production continuing to increase annually until 1921.

And now for the third time in eighty years, American farmers find it necessary to produce foodstuffs on an unprecedented scale. Also, for the third time, the farm machinery manufacturers are ready with new designs of more efficient machines with which to do the job, but for the first time there is a distressing lack of materials out of which to build the machinery needed.

Just how do other countries look upon food, farm machinery, and the war?

The number of tractors has doubled in Great Britain, from 52,450 early in 1939 to approximately 110,000 early in 1942. Nothing at home nor abroad is permitted to interfere with the manufacture, shipment, and delivery of tractors to Great Britain. In the February 1, 1942, issue of "Implement & Machinery Review" of London is the following significant statement by S. J. Wright, director of the Institute for Research in Agricultural Engineering: "Our agriculture is probably more fully mechanized than that of any other country in the world. . . . . Speaking very broadly, America has one tractor to every two square miles,

Paper presented July 1, 1942, at the 35th annual meeting of the American Society of Agricultural Engineers at Milwaukee, Wis. Author: Agricultural engineer, J. I. Case Company.

EDITOR'S NOTE: Readers interested in a more exhaustive treatment of the subject of this paper are referred to an address, entitled "Food, Farm Machinery, and War", delivered by the author before the Eighth Annual Chemurgic Conference at Chicago, March 25, copies of which may be obtained from National Farm Chemurgic Council, Columbus, Ohio.

while we have one to something like half that area." This is indication of the great determination with which Great Britain insists upon having the necessary farm machinery with which to produce as much as possible of vitally important food.

In the "Implement & Machinery Review" for February 1, 1941, we find significant information on farm mechanization in Germany: "Agricultural engineering generally is now recognized in Germany as 'one of the greatest war weapons'. Its contribution to the battle of production . . . is held to be fundamental. . . . It is even claimed that the previous record of yearly production figures of 1927 have been exceeded during the war period by no less than 50 per cent. Contributing most noticeably to these new record figures is the fact that German output of tractors has increased fivefold in the last three years." In "Foreign Agriculture" for October 1941 is this thought-provoking sentence: "It is significant that apparently a considerable increase in the manufacture of farm equipment, including tractors, took place in Germany on the eve of the Russian-German war."

In the same issue of "Foreign Agriculture" appears this statement regarding Russia: "Recovery from the catastrophic reduction in the number of horses during the early years of collectivization has been slow, in spite of much stress laid in official Soviet pronouncements on the usefulness of the horse. In 1938 there were only 17.5 million horses, as compared with 34.6 million in 1929 and 35.8 million in 1916. However, nearly half a million tractors have been working in the fields during the past few years, and Russian agriculture can be said to have reached the tractor age, partly by design and partly by the accident of the destruction of the horse."

FARMERS PRODUCED MORE IN DEPRESSION YEARS BECAUSE PLENTY OF LABOR WAS AVAILABLE

Here in America the U. S. Department of Agriculture has a Food-for-Victory program so extensive that hardly a day goes by that the importance of food is not emphasized by something we read in the daily press or hear over the air. An acute labor shortage exists on American farms, and it will continue to get worse until the war is over. In 1941 the farm machinery manufacturers could not supply the demand, and in 1942 less than 50 per cent of the farmers wanting machines could buy them. Where a year ago this summer the manufacturers had a reasonable inventory in their warehouses and branch house stocks, the same being true of implement dealers, that inventory is now wiped out. The significance of this lies in the fact that it was this inventory plus 83 per cent of 1940 from which Southern farmers could buy new equipment and repair parts. But, for the 1943 year, beginning in the South the latter part of August or early September, there is no inventory this year to draw upon, and material for the manufacture of machines for 1943 has not yet been released.

It has been argued that farmers produced large crops in the depression years of the thirties without buying equipment, but this argument overlooks the fact that farmers then had plenty of help. Many members of farm families had come back from the city, so there was plenty of labor, and, when desired, the machines could be run in two or even three shifts without difficulty. Today the farmer is dependent mainly on the help of the aged or the young, many of whom are from towns and cities, and unfamiliar with the operation of farm machines.

Farmers, their wives, and children know nothing about a 40-hour week and time and a half and double time for overtime. They work long hours. The need for farm machinery, therefore, is much greater than is recognized by those responsible for allotting materials for the manufacture of equipment with which to carry on American agriculture. The only way the food needed by ourselves and our allies can be produced is to have available sufficient farm machines. To produce these machines more materials are required than now appears likely to be allocated in 1943.

It should never be forgotten that food, as ammunition for the stomachs of our soldiers, is just as important as ammunition for their guns.

Terrace Construction by Plowing

(Continued from page 284)

generally in good condition, and there is no extra work for a farmer to get ready.

3 Terraces are constructed more economically with a plow than with some of the conventional terracing machines.

4 One man can do the job — an important factor in this time of farm labor shortage.

5 A farmer uses the same methods for maintenance as for construction. Consequently he is better prepared to know how and when the terrace needs maintenance.

6 Farmers who practice contour farming can easily build terraces without special assistance. Laying out contour lines at terrace spacings and grades expedites this work.

Some of the cautions to be exercised are:

1 Do not start terrace construction until the terrace system has been designed and satisfactory terrace outlets are established.

2 Do not start on too many terraces at one time. Build each one sufficiently high to afford protection before starting construction on another.

3 Build the top terrace first and work downhill, taking each terrace in succession.

4 Do not give up with the plow method until several replowings of the once-plowed soil have been made. Just because the plow doesn't scour is no sign that you are not moving the soil.

About 30 farmers in the Montgomery Soil Conservation District in southwest Iowa have been using this method of terrace construction, and about as many more plan to adopt it in their terracing program this year.

A Montgomery district survey shows that 5,518 miles of terraces are needed in the district. If these terraces are built in a reasonable time, every farmer will need to start soon and to use an economical and simple construction method. By the plow method, many of these farmers can build their terraces as fast as they need them and at a time when it will least interfere with crops.

Several other systems of terrace construction with a plow have been adopted by farmers in various parts of the country. They vary considerably in procedure. This one gives satisfactory results.

The Part of Ag Engineers

RIGHT now the one job of the nation is to win the war. The part of agricultural engineers in this job is twofold, namely, that as citizens in giving moral and financial support and service in the armed forces, and as professional engineers in serving agriculture. It is up to us to see that the engineering end of agricultural production keeps up with the tempo of war. It means quick adjustments to meet changing demands. There must be no monkey wrenches in the machinery.

The Improved Single-Impulse Electric Fence

By Charles F. Dalziel

THE improved single-impulse electric fence is the result of investigations made at the University of California to develop a safe and effective fence controller. Although the improved design is not covered specifically in the various safety codes, it is believed that it will be found to conform to the intent of the present regulations. Modifications of at least two of the safety codes are now under consideration, and it is anticipated that the matter of allowable leakage current, the only technical specification not met in full by the proposed device, will receive adequate consideration. A rather complete discussion of the principles used in electric fence controllers, together with their advantages, disadvantages, and hazards, was published in AGRICULTURAL ENGINEERING[1] for November 1941. The present paper covers the single-impulse device only, and reference should be made to the original article for comprehensive treatment of other types.

Single-Impulse Controller. The principal advantage of the single-impulse electric fence controller is that it allows one, and only one, single powerful impulse electric shock to be delivered to an animal or human when it contacts the electrically charged fence wire, regardless of the duration of the time of contact. Then if for some reason the animal or human fails to free himself from contact with the fence wire after the first impulse, the sustained current is reduced to such a small amount that the effects are harmless, even if endured for a long time. In the proposed design, both the initial single-impulse shock and the sustained current are harmless to animals and to normal human beings, including children. Actual use has demonstrated that this device obtains the above important results. In cases where the safety codes covering electric fences are not in accord as to details, the most conservative value may be satisfied. In addition, where essential electrical safety specifications are not included in the codes, the design contemplates the use of safe values determined from experiments made on humans and animals.

The fundamental circuit of the single-impulse controller is shown in Fig. 1. The device is supplied from an ordinary 115-v alternating-current lighting circuit which energizes the primary winding of the transformer (P). The high voltage obtained from the secondary of the transformer (S_1) is rectified by the thermionic tube rectifier (V.T.) and impressed on the filter (Z, C, and R), thence to the controller terminals. The low voltage obtained from the secondary of the transformer (S_2) is utilized to heat the filaments of the rectifier tubes.

Article prepared especially for AGRICULTURAL ENGINEERING. Author: Associate professor of electrical engineering, University of California.

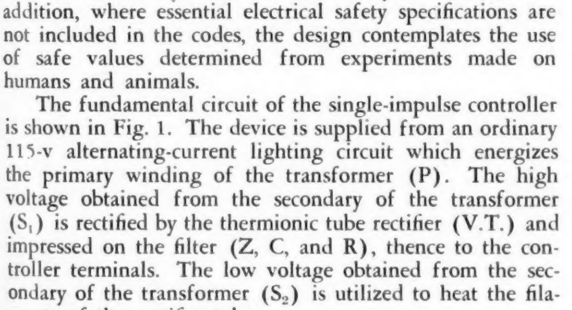

Fig. 1 The fundamental circuit of the single-impulse electric fence controller

One or more bare wires electrically insulated from the ground, and placed at a proper height above ground to be effective in controlling animals, are connected to the negative output terminal. This is desirable because a more powerful sensation is produced when the fence wire is of negative polarity. A connection to ground, or to ground and also to a second system of bare ground wires to permit ready contact by animals, is made to the other output terminal as indicated in the figure.

The operation of the device is as follows: A relatively high voltage is maintained between the fence wire and ground, due to the charge on the condenser (C) and to the fact that the fence wire or wires of opposite polarity are electrically insulated from each other. Any conducting object coming into electrical contact with fence wires, or between the fence wire and the ground, will cause the condenser to discharge, and thus instantly deliver a single-impulse shock on contact. An animal will receive a shock on each new contact when preceded by a break in contact. If an animal or person retains contact with the fence wire, the impulse shock rapidly decreases in magnitude to a safe sustained current, from which contact may easily be broken as soon as recovery from the sudden surprise permits voluntary muscular action.

Figs. 2 and 3 show typical oscillograms obtained from experimental units using half-wave and full-wave rectifiers constructed in accordance with Fig. 1, and illustrate the single-impulse discharge and the subsequent drop in current to the safe range. Prior to contact with the fence wire, the current zero line is shown at *A*. Regardless of how long a human or an animal remains in firm contact with the fence wire, he receives one and only one powerful shock, illustrated by the instantaneous rise of current to the point *B* at the moment of contact. Then the ensuing safe sustained d-c and the superimposed a-c ripple produced by the pulsating high voltage rectifier are limited to values safe for animals, adults, and children. This total safe sustained output current comprising the d-c and a-c components is shown at *G*. See particularly Fig. 4, wherein the a-c ripple has been intentionally increased so as to be clearly apparent.

The safe or allowable a-c components are shown in Fig. 5. The safe let-go current curves were determined in a manner similar to those of Fig. 2 of the reference[1]. However, crest values of the a-c component were used to permit analysis for complex wave shapes, and additional experimental data together with refinements of analysis give a considerable increase in accuracy. As discussed in the reference[1], safe values for children were estimated as one-half the safe values for men; values for women were determined from tests completed since publication of the original paper.

Allowable values of condenser charge, maximum impulse current, sustained d-c output, and the a-c content of the sustained output current are obtained, as hereafter stated, by proper selection of the no-load voltage *E*, capacity of condenser (C), and the impedance of impedors (Z and R).

The advantages of this combination are as follows:

1 A single powerful, short-lived impulse shock current (*B* on Figs. 2, 3, and 4) has been found to give very effec-

1 "The Electric Fence" by Charles F. Dalziel and James R. Burch, AGRICULTURAL ENGINEERING, vol. 22, no. 11, November 1941.

tive results on cattle. It can be taken by humans without injury.

2 Regardless of how long a person or an animal remains in firm contact with the fence wire, he receives only that one powerful shock because the current drops rapidly to a very small and safe value (*G* on Figs. 2, 3, and 4). This is in striking contrast to the torture of a victim, man or animal, if for some reason he should be unable to free himself from an electric fence energized by any of the intermittent electric fence controllers now in use, which repeat the shock with full force at periodic intervals.

3 The victim may easily release his grasp of the fence wire after the current has substantially decreased from its initial value (*B* on Figs. 2, 3, and 4), and when recovery from sudden surprise permits doing so. An important point is that regardless of the time lag of muscular paralysis and the effect on the nervous system caused by the initial shock, the victim will not be subjected to further shocks and may release himself when composure permits. The sustained output current (*G*), to which the victim is subjected following the initial shock, may be endured for extended periods with no serious effects.

4 Its effectiveness for animals is important. Many animals pause for a moment before a barrier, and make an investigation with their noses before proceeding. The single-impulse fence delivers one powerful shock, and that one instantly on contact. Under these circumstances the animal receives the full discharge on its most sensitive (and wet) extremity. Unless the animal is frightened into a rage, experience has shown that it will probably turn back after one or two such shocks and leave the fence alone.

With the intermittent types of electric fences, the animal will receive the shock on first contact of its nose with the wire, only if the on-period happens to coincide with this contact. If the timing is such that the animal does not receive a shock when its nose contacts the wire, difficulties may ensue. For example, it may start under the wire and receive the shock on its back or tail. In that event, it is likely that instead of being repelled, it may jump clear of the fence in a forward direction, or it may be unaffected by the shock due to poor contact.

5 The controller keeps the fence continually on the alert. The potential on the single-impulse fence begins to build up the moment contact with the fence wire is broken. Thus the condenser immediately begins to recharge and quickly becomes ready to deliver a second shock to the same or to a second animal. This is in contrast to the intermittent types wherein the interval between on-periods is usually 0.75 to 1.0 sec.

Improved Single-Impulse Controller. The circuit of the improved single-impulse electric fence controller is shown in Fig. 6. This form is preferred because of the inherent simplicity and the separation of the primary power supply from the output circuit. Fig. 7 shows an alternate circuit with current interruption on the primary side.

The present safety codes limit the sustained current output of a condenser discharge type of electric fence controller from 0 to 5 ma (milliamperes), depending upon the particular safety code considered[2]. Experience has shown that this current is insufficient to supply normal insulation leakage currents for the average length of fence now in use. A current of this magnitude is so small that it has been found difficult, if not impossible, to maintain the fence at a sufficiently high potential to secure effective control of animals, except under ideal operating conditions. The problem, therefore, has been to provide a device which will give this low current during the normal time interval usually required for a victim to release himself after receiving a shock from the fence wire, but which would permit considerably larger currents to flow during times of excessive insulation leakage and thereby maintain the effectiveness of the device during both favorable and unfavorable operating conditions.

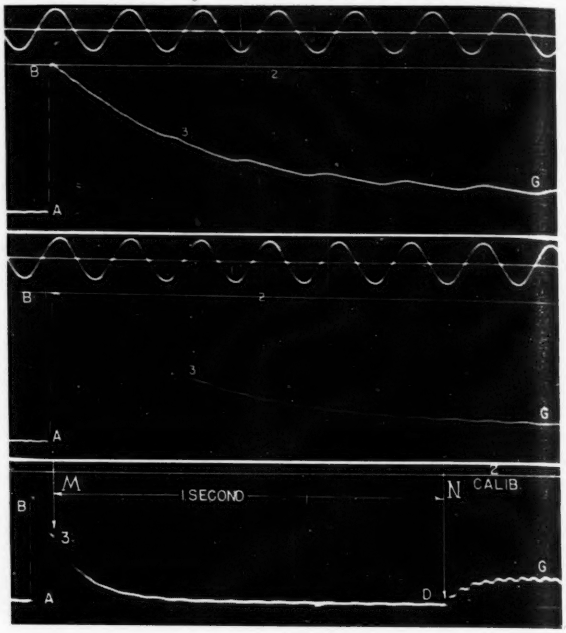

Fig. 2 (Top) Oscillogram from single-impulse controller, using half-wave rectifier. (*1*) 60-cycle timing wave, (*2*) calibration, (*3*) output current, (*A*) current zero, (*B*) impulse current, (*G*) sustained current, (*R*) 17000 ohms, (*Z*) 26700 ohms, (*C*) 2 mfd, (*E*) 1750 v. External resistance, 500 ohms

Fig. 3 (Center) Oscillogram from single-impulse controller, using full-wave rectifier. (*1*) 60-cycle timing wave, (*2*) calibration, (*3*) output current, (*A*) current zero, (*B*) impulse current, (*G*) sustained current, (*R*) 17000 ohms, (*Z*) 53300 ohms, (*C*) 2 mfd, (*E*) 1750 v. External resistance, 500 ohms

Fig. 4 (Bottom) Oscillogram from improved single-impulse controller, using full-wave rectifier. (*2*) Calibration, (*3*) output current, (*A*) current zero, (*B*) impulse current, (*D*) sustained current, (*G*) leakage current, (*M*) relay contacts open, (*N*) relay contacts close

Fig. 4 shows the results obtained with the device of Fig. 6. Note the dip of current output to line *D* immediately following the single impulse, which raised the current to *B*. If a person or an animal retains contact with the fence wire, the current will gradually rise to *G*, which is identical with the sustained current obtained from the device of Fig. 1 shown in Figs. 2 and 3. It should be pointed out that except for the most extraordinary circumstances, a person or an animal would break contact with the fence wire when the current had decreased to substantially value *D*, and before the current had begun to increase to *G*. If current represented by *D* is limited to 5 ma, it is so small that it can hardly be felt. The threshold of perception for pure direct current with an electrode held in the hand is 5.2 ma. For sinusoidal alternating current, the threshold is 1.5 crest ma (1.1 rms ma).

The increased safety inherent in the single impulse is forcefully illustrated if the output characteristics of this device are compared with the recurrent shocks delivered by

2 Safety Rules for Electric Fences, Part 6 of the Fifth Edition *National Electrical Safety Code*. April 17, 1940.

Standard for Electric Fence Controllers, Underwriters' Laboratories Inc., September 1939.

General Orders on Electric Fences, Industrial Commission of Wisconsin, October 1938.

Specifications and Tests for Electric Fence Controllers, Public Utilities Commission, State of Connecticut, March 1938.

Specifications — Electric Fence Controllers, State Welfare Commission, State of Oregon, December 1936.

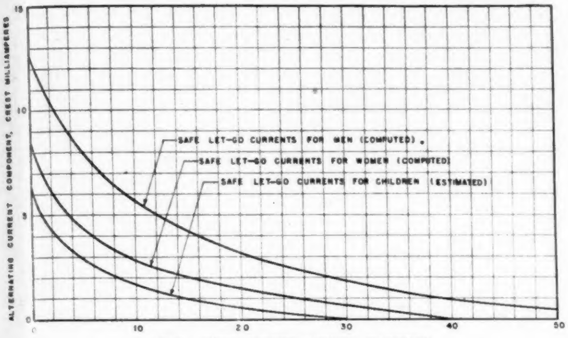

Fig. 5 Safe let go currents

an intermittent controller of the condenser discharge type. If contact with the fence is maintained, both types produce a discharge similar to that of Fig. 4 up to point *D*. In contrast to the single-impulse discharge, in which the output current gradually increases to *G*, the intermittent controller delivers a second shock of full intensity (*B* on Fig. 4). These recurrent shocks continue at approximately one-second intervals for as long as contact is maintained with the fence wire.

An instantaneous-opening time-delay-closing relay is used in the improved device to obtain the current drop to *D*. The purpose of the relay is to accelerate the rate of collapse of the discharge current from *B* on Figs. 2, 3, and 4 to the low value *D* on Fig. 4. Note that *D* represents a smaller current than *G*. This adds greatly to the safety of the device. After the relay contacts close, the current gradually increases, still within the safe range, to its final value *G*.

The relay also materially reduces the fire hazard when contact of inanimate conducting objects create arcing in the vicinity of combustible materials, since the small sustained current *D* is insufficient to maintain a high-voltage arc. Any arcing contact should result in relay operation the instant an arc forms, and produce a repetition of the cycle. It is believed that the characteristics of the circuit are such that leakage current *G* is prevented from creating a fire hazard. In any event, it should not exceed that caused by an intermittent capacity discharge controller having the same impulse and sustained currents (*B* and *D*, Fig. 4, respectively).

The single-impulse discharge is obtained by the substitution of a low leakage current in place of recurrent shocks. Leakage current, that is, a direct current with a small a-c ripple superimposed thereon (current *G*, Fig. 4) is not covered in any of the present safety codes. However, the subject is now under investigation by several independent authorities, and modifications of at least two of the safety codes are under consideration. It is anticipated that both sustained current and leakage current will receive adequate consideration which should result in clarification of the issue. Authorities with field experience are of the opinion that a leakage current of at least 15 ma d-c is necessary to obtain effective results during adverse operating conditions. A controller capable of supplying a leakage current of 25 ma d-c should give performance superior to any commercial device now on the market.

Impedor (R_B, Fig. 6) is connected across the contacts of the relay to increase the effectiveness of the controller during times of low leakage current. This is accomplished by permitting the condenser (C) to recharge immediately as soon as an animal breaks contact with the fence wire, that is, without having to wait for the relay contacts to close. The resistance of impedor (R_B) is such that it may feed a little but not much current to the fence wire. Thus the current (D) is not quite zero. However, it permits the condenser (C) to recharge once contact with the fence is broken, and the fence rapidly becomes ready to deliver a second shock to the same or to another animal regardless of the time delay provided by the relay.

It is realized that it is impractical to provide adequate protection against direct lightning strokes for any device of this kind. The small lightning arrester (Fig. 6), connected directly across the output terminals will protect the condenser from minor static disturbances and from the effects of distant lightning discharges. The purpose of the arrester is to protect and prolong the life of the condenser and thereby reduce maintenance costs.

The indicator, Figs. 6 and 7, is inserted to give an indication of the operating condition of the controller and the leakage resistance of the insulated fence wire to ground. The indicator may consist of a milliameter with a scale marked to indicate leakage current in milliamperes. It may be marked to indicate the approximate condition of the fence insulation from ground, such as perfect, good, average, and short circuit. The indicator also provides an indication in the event either the condenser or the lightning arrester becomes short circuited. It is thus apparent that the sole purpose of the indicator is to provide a visual indication of the electrical conditions existing in the controller or along the fence as an aid in maintaining proper operation. It in no way alters the fundamental principle of operation.

It may be desirable to provide a transparent cover over the controller assembly so that certain moving parts of the relay will be visible to an attendant. Operation of the relay indicates proper functioning of the controller when good contact is made with the fence wire. Failure of the relay to operate when a shock is produced by contacting the fence

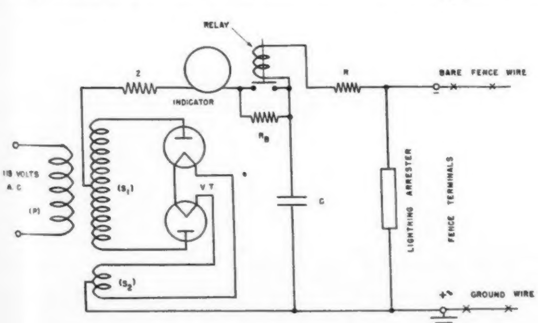

Fig. 6 Improved single-impulse electric fence controller

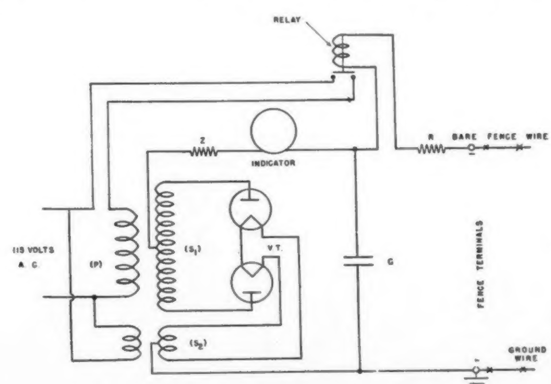

Fig. 7 Alternate single-impulse electric fence controller

wire, indicates the presence of a defect in the controller, for instance, an open-circuited condenser. Thus a ready means of ascertaining proper operating conditions is provided. This is of value in field inspection of controller installations.

Selection and Adjustment of Circuit Elements. It is important that the fence wire be maintained at a high potential with respect to ground so as to produce sufficient shock to control animals, regardless of wide variations in ground resistance and contact resistance of the animal. This is accomplished by choosing a suitable voltage for the transformer secondary winding (S_1) and the correct values for impedors (Z, R), and condenser (C), so that the fence is maintained at a relatively high voltage, irrespective of ordinary fence insulator leakage currents. Very high voltages are likely to cause insulation problems and excessive leakage currents, and due to the limited output this might result in a low fence voltage and unsatisfactory operation. A maximum no-load d-c output voltage E of 1,000 to 3,000 v should be satisfactory.

The safety codes limit the maximum stored energy of the condenser (C) to $3\text{x}10^{-3}$ coulomb. The capacity of the condenser is determined from the relation, $C = Q/E$, in which C is the capacity of the condenser in farads, Q is the charge in coulombs, and E is the output voltage defined in the paragraph above.

The maximum impulse current B is limited to a safe value by impedor (R). This current must not exceed the requirements of the particular safety code under consideration when the fence terminals are connected through a 500 ohm non-inductive resistor. If impedor (R) is non-inductive, and the impedance of the relay coil is relatively small, an approximate and conservative value of the maximum impulse crest is determined from the relation $R = E/I$, in which R is the resistance of impedor (R) in ohms, I is the crest value of impulse current, and E is the d-c no-load output voltage.

Safety code requirements for intermittent electric fence controllers specify an on-period not to exceed 0.05 to 0.10 sec, followed by an off-period of approximately 1.0 sec. The relay therefore should be equipped with a suitable escapement mechanism, or other timing control, to permit rapid opening and a definite contact closing time delay of 1.0 sec.

In order to provide a maximum degree of safety, the relay should be set to operate for steady currents slightly in excess of the leakage current G, i.e., the final or permanent current developed with the relay contacts closed and with the fence terminals short circuited. This is to insure relay operation on very high contact and ground return circuit resistances and to prevent unnecessary relay operations and accompanying wear and tear due to pumping action. If the relay were set to operate on steady currents less than this value, unnecessary relay pumping would result from accidental short circuits between the fence wire and grounded objects.

The next step is the proper selection of the leakage current G. Here there are several considerations. Due regard must be given to the probable safe let-go current of a two-year-old child on the assumption that he may fail to release himself from the fence wire during the off-period provided by the relay; or that for some unforeseen reason the relay contacts remained in the closed position and the current went from B directly to G. The safe-let-go-current curve for children, Fig. 5, indicates a maximum safe pure direct current of 30 ma. Allowance must be made for reasonable leakage currents in order to obtain effective control of cattle under the ordinary conditions found to exist in the field. The maximum leakage current should not be excessive in order that the power consumption, and hence the operating cost, be kept within reasonable limits. It is believed that the direct-current component in the current G should be limited so as not to exceed 25 ma. With B, C, and R fixed as discussed above, the sustained current G is controlled by impedor (Z).

The proper value of impedor (Z) is best selected by actual measurement and adjustment on the unit after the other circuit elements have been set. Having tentatively selected a reasonable value for sustained current G, it is also necessary to measure both the crest value of the alternating-current component and the direct-current component, to be sure that the components of the output current G are within the limits of the safe-let-go-current curve of children as shown in Fig. 5, when fence terminals are short circuited through a 500-ohm non-inductive resistor. Compliance with the safe-let-go-current curve is accomplished by proper selection of the ratio of inductance to resistance in impedor (Z), or by increasing the resistance of impedor (Z) with a reduction in the sustained current G, or by changes in the other circuit elements.

The sustained current D (i.e., the sustained current developed with the relay contacts blocked open) must be limited to a value between 0 and 5 ma, depending upon the safety code considered. This is accomplished by selection of impedor (R_B) with the fence terminals short circuited through a 500-ohm non-inductive resistor. The a-c and d-c components of current D must then be checked with the safe-let-go-current curve, as described previously.

With the various circuit elements adjusted, as specified above, a final check is made to determine that the discharge from the controller is non-oscillatory. This is necessary since the inductance of the relay coil, together with the condenser, might be such as to cause an oscillatory discharge instead of producing the single impulse B, and thereby create objectionable radio interference. This check is best made by taking an oscillogram of the output current with fence terminals connected through the low resistance current element of an ordinary oscillograph. A calibrated oscillogram also gives a positive check on the output characteristics and provides an accurate evaluation of current and time values.

If the circuit elements are chosen with regard to the range of values suggested, and if impedor (R) is non-inductive, the circuit resistance will be above the critical value for oscillation. In the event the discharge is oscillatory, the difficulty may be eliminated by decreasing the inductance of the relay coil and/or increasing the resistance of impedor (R).

SUMMARY

The single-impulse electric fence controller possesses two advantages over all other types, as follows: (1) Safety. Regardless of the time of contact with the fence wire, a human being or an animal receives one and only one single powerful shock. (2) Effectiveness. The fence wire is maintained ready to produce a shock instantly on contact at all times.

Safe values of the components of leakage current are presented graphically. Limiting values, which are believed safe for normal adults and children, were determined from hundreds of experiments made on men, women, and a few children.

It is believed that an improved single-impulse electric fence controller with a reasonable leakage current allowance should give performance superior to any commercial controller now available.

Soil Admixtures for Earth Walls

By R. L. Patty

MEMBER A.S.A.E.

IN THE research studies of earth construction at the South Dakota Agricultural Experiment Station, and particularly with rammed earth or pisé construction, various materials have been mixed with the soil from time to time and their effect noted. These admixtures generally affect both the strength and weather resistance of an earth wall. During the early years of the study the effect upon the strength of the wall was given considerable attention, but later it was found the strength was of minor importance and attention has been given largely to weather resistance. Earth construction has ample strength for low type buildings, but we do not believe it has any place in the construction of high buildings. One or two-story farm buildings can be constructed of earth, with a good factor of safety in strength, from any soil that has sufficient resistance to weathering. Soil that does not have this weather-resistant quality is unfit for use. Dependable and accurate tests for weather-resistant soils have been developed at the South Dakota station, and tables have been worked out for quality ratings and for recommended amounts of sand admixtures for improving low quality soils. It is highly desirable that all builders using rammed earth have a laboratory analysis made of the soil.

When rammed earth walls are to be stuccoed, soils of average or better quality can be used. The only advantage of high quality soils under stucco would be in case the stucco work was not done correctly and repairs to it were neglected. High quality soil for rammed earth can be made by adding sand to any soil that shows by test to be fit for use.

Admixtures of Sand. At the beginning of the study it was apparent that sand was an effective and practical admixture to use in most rammed earth soils. Probably not more than 10 per cent of the farms over the entire United States would have a soil that would rate as high quality without any admixture of sand. Eighty per cent of all farms would have soil that is fit to use and could be improved to a high quality soil by adding sand. Some sand was added to adobe brick in the past, and today, with more study being given to the quality of adobe soils, sand is being added to most adobe brick.

In discussing admixtures we use the term sand as including all aggregates. The difference between adding screened sand and adding bank-run aggregate is not important. Some prefer to screen out the coarse aggregate from the admixture before using it because of the effect upon the appearance of the wall.

Coarse aggregate in the admixture had practically no effect upon the weather resistance of a wall over the use of sand only. Neither did the size of sand particles seem to have any effect upon the weather resistance of the wall. In the experimental yard at Brookings we have two weathering-test walls that have been standing since 1930. Each of these walls was built from soils just as it was dug up, and both soils are high quality, containing around 75 per cent total sand. One of the walls contains nothing but very fine sand, all of which would pass a No. 8 screen. The other wall contains well-graded aggregate in sizes from the finest sand to aggregate 2 in in diameter. Both of these walls are in perfect condition after 12 years of weather exposure. Well-graduated aggregate will affect the strength of a wall in compression, but the difference is negligible so far as practical building is concerned. In no case would it be necessary to consider this fact in choosing a material which is to be used for an admixture. Two experimental series were set up and carried out on the effect of size and proportions of aggregate used in the soil upon the strength of the wall in compression. Aggregate sizes from very fine to 1/4 in increased the strength very slightly up to 45 per cent total sand content. An admixture of sizes from 1/8 to 1/4 in increased the strength slightly more than any other, with sizes of 1/8 in to very fine showing second strength. As the size of aggregate increased above 1/4 in the strength decreased. Additions of sand to a soil containing 50 per cent total sand decreased the strength in compression materially, but it increased the weather resistance of the wall, which is definitely more important.

Admixtures of Cinders. Tests have been carried on to see if coal cinders could be used as an admixture in a rammed earth wall in place of sand. The effect upon the strength of the wall was tested as well as upon the weather resistance. Three walls were built for testing the weather resistance. One of these was a check wall made from a No. 2 base soil which is of medium quality and containing no cinders; one wall was rammed from two volumes of No. 2 base soil and one volume of cinders (33 1/3 per cent cinders); and one was rammed from one volume of No. 2 soil and one volume of cinders (50 per cent cinders). The soil for the three walls was taken from the same stock pile. It was a medium quality soil containing 46 per cent total sand that would not stand up as a bare wall and that needed an additional admixture of sand. The cinders used were Illinois soft coal cinders from a power plant and were fairly hard and well graded. The test walls were built on December 1, 1937, and have stood slightly more than four years. The walls are roughened about the same as walls of this same base soil containing the same admixture of sand. They will not stand as bare walls but would be very satisfactory for stuccoing. The cinders reduced the coefficient of shrinkage in the same proportion as sand, and the cinder walls are weathering far better than the check wall, which contained no admixture.

TABLE 1. EFFECT OF ADDING SAND AND CINDERS TO SOILS IN RAMMED EARTH WALLS UPON THE STRENGTH IN COMPRESSION

Kind of Soil, original sand content (hydrometer anal.)	ULTIMATE LOAD, LB PER SQ IN AVERAGE		
	No Admixture (Check blocks)	33-1/3% admixture by volume	50% admixture by volume
Black clay soil		Of sand 388	Of sand 374
26% sand (by wt.)	527	Of cinders 374	Of cinders 313
Yellow medium		Of sand 495	Of sand 363
46% sand	542	Of cinders 490	Of cinders 400

Test pieces 9x9x9-in cubes and each strength figure is the average of three like test pieces.

A study was also made to test the effect of cinder admixtures upon the strength of the wall and to compare with strength of walls with sand admixtures. The results are shown in Table 1. Two base soils were used in this study; one a heavy black soil and the other a medium yellow soil. Identical test pieces were made from each

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soil. The mixing of 33⅓ per cent, by volume, of cinders gave an average compressive strength of 1.2 per cent less than an equal amount of sand. The mixing of 50 per cent cinders gave an average strength almost exactly the same as for an equal amount of sand. The heavy soil showed greater strength for the sand admixture, but the medium soil showed an equal advantage in strength for the cinders. Both admixtures showed a decrease in strength from the original soil or check pieces, as expected. The difference in this series, as shown in the table, is somewhat greater than the average for most soils, but when 33⅓ per cent of sand is added to a soil already containing 46 per cent sand (hydrometer analysis*), it brings the total sand up to 60 per cent which is too high for maximum strength.

Admixtures of Portland Cement. The first admixture of portland cement to rammed earth was made at the South Dakota station in 1932 when just a few test pieces were made with a cement admixture as a preliminary test. The pieces made from soil containing a large amount of sand and especially of fine sand showed a remarkable increase in strength, while soils containing small amounts of sand showed a very small increase. In 1935 a special test was set up for determining the effect of a portland cement admixture on the compressive strength of rammed earth walls and also the relation of the sand content of the soil to the strength due to the cement admixture. Four soils were used in the test and 15 per cent of cement by weight (on air dry basis) was mixed with 85 per cent of each soil. The soils were chosen with varying amounts of total sand content, but the increment of increase was not exactly uniform, as shown in Table 2. Three of the soils were natural soils containing the original sand ratio. They were used in test pieces A, B, and D. Test pieces C were made from soil B with sand added, up to 65 per cent. The figures in the table are for the ultimate load carried by the test pieces which had a depth of 9 in. (Test pieces with a depth of 4 in would have shown a strength 97 per cent greater than these, or approximately double.) It is apparent from these figures that portland cement is practically wasted when added to soils of low sand content, but for sandy soils and particularly fine sandy soils the increase in strength is remarkable.

TABLE 2. EFFECT OF A 15 PER CENT ADMIXTURE OF PORTLAND CEMENT UPON THE STRENGTH OF RAMMED EARTH WALLS CONTAINING VARYING AMOUNTS OF SAND IN THE SOIL

No. of test piece and type of soil	Total sand in soil by hydrometer anal., %	No admixture	15% portland cement admixture
A–Black clay loam	26	358	445
B–Yellow sandy clay	46	595	976
C–Yellow sandy clay with sand added	65	447	989
D–Very fine sandy loam soil	74	302	1150

Test pieces, 9x9x9-in cubes; each strength figure is the average of four like test pieces.

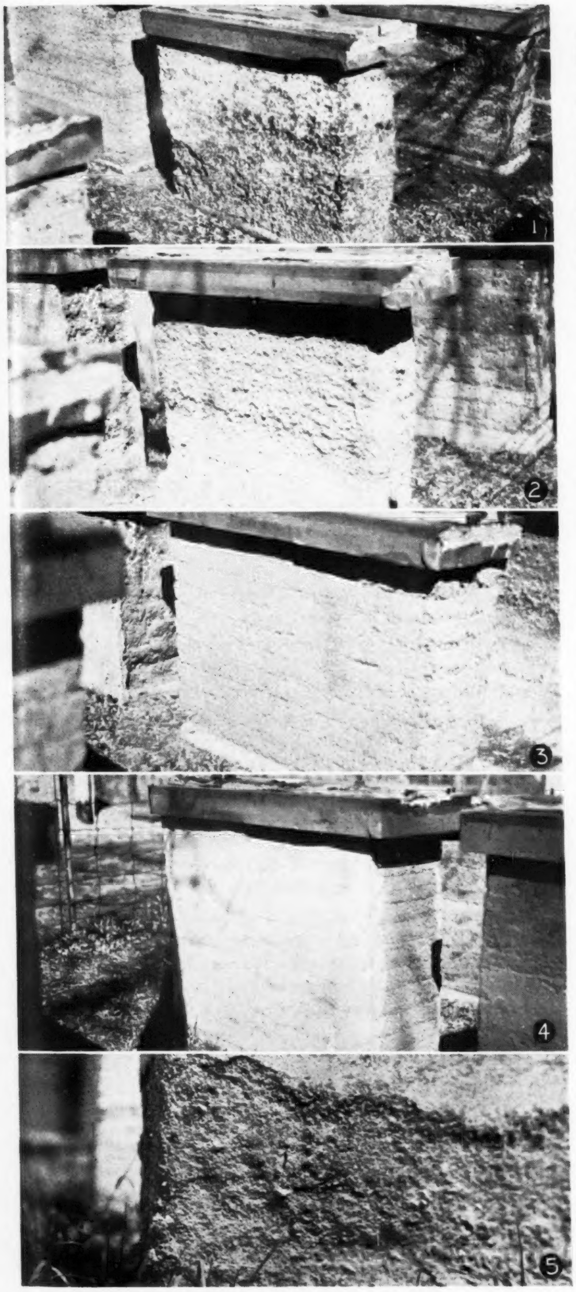
Since we were not particularly interested in admixtures in our study, which has to do with farm buildings, no soil-cement walls were built for the weathering test until 1940. On August 7 of that year a soil-cement test wall was built in the yard, and cement was used in "plating" two other test walls. In the soil-cement test wall a mixture of three parts of a medium soil was made with two parts of sand to bring the total sand up to 70 per cent which would make it quite favorable for a cement admixture. To this mixed soil was added 5 per cent of portland cement by volume. During the following winter the lower 10 in of this wall was damaged badly from snow and ice which drifts into the yard each winter (Fig. 5). The results were sufficiently conclusive to show that an admixture of 5 per cent of portland cement to rammed earth soil is insufficient. However, the wall was taken down and a new wall built in its place with the same admixture of cement, but this time more sand was added, bringing the total sand content up to 75 per cent. By the side of this wall was built another using exactly the same soil mixture and adding 10 per cent of portland cement by volume; viz., 9 measures of soil and 1 measure of cement. These two walls were built July 30, 1941, and came through the winter satisfactorily. The winter was comparatively open, however, with few snow storms. The cost of adding 10 per cent of portland cement for a soil-cement wall was $1.01 per inch in thickness per square of wall (100 sq ft) with cement at 75c per cu ft (sack).

An Admixture of Tannic Acid. A chemist in a university laboratory of a neighboring state tried several laboratory materials for stabilizing rammed earth and reported tannic acid as showing some advantage in hardening test samples. A series of test pieces were made up for testing this quality in which varying amounts of tannic acid were used, ranging from 13 g per cwt to 104 g per cwt. Penetration tests did not reveal an appreciable advantage in hardness from the tannic acid. It was added in the mixing water. A wall was built with a tannic acid admixture by the side of an identical check wall, minus the tannic acid, in August 1939. These walls are weathering sufficiently now so that dependable results can be predicted. No difference in their weathering rate is evident after nearly three years. It is safe to say that the tannic acid has done no harm in the wall, but it has in no way improved it.

An Admixture of Common Salt. Common salt has been used as a road base stabilizer in Canada, and it was given a test as an admixture for rammed earth. No test was made on its effect upon the strength or hardness of the wall, but it was tested for its effect upon weather resistance. A medium soil containing exactly 50 per cent total sand was used to which was added 2 lb of coarse stock salt to 100 lb of soil. A check wall was rammed from the same soil containing no salt and immediately adjacent to the test wall. The walls were built in August 1939. The wall containing salt has remained damp continuously since it was built, drawing moisture in the same way as does calcium chloride in dust prevention. It began showing signs of crumbling within a period of three months. At the end of a year it was crumbling badly, and at the end of two years had lost fully one inch in depth from its surface on all sides. It has now been standing nearly three years and may fail completely in another year or two (Fig. 2). The check wall is still standing in good condition, but will soon begin to show some weathering effects as it is not a high quality soil.

An Admixture of Fiber. Fiber, when mixed with the soil in reasonable amounts, did not injure a rammed earth wall in any way, unless it was in appearance. There is no harm in taking some grass roots and grass fiber up with the soil. Some writers have given a wrong impression in this regard. Fiber increased the strength in a series of 28 test pieces made and tested in the laboratory for strength in compression. Out of the 28 specimens tested only four fell below the check specimens in compressive strength, and they only slightly. All other pieces averaged around 15 per cent higher in strength. Where a wall is to be stuccoed, there would be no point at all in screening out fibrous material. The maximum amount would be the point where the fiber would be reasonably well separated and not bunched in the wall. Table No. 9 in South Dakota station Bulletin 277 gives the details of this compression test.

*Total sand according to an analysis with the 200-mesh sieve for this soil was 37 per cent.



TEST SPECIMENS OF EXPERIMENTAL RAMMED EARTH WALLS

Fig. 1 An admixture of 50 per cent cinders by volume. This wall has stood five years with an admixture of cinders in place of sand. The soil used was below average in quality. The cinders reduce shrinkage of the soil and cracking of the wall as well as does sand. The wall is rougher but would make an excellent surface for stucco • Fig. 2 An admixture of common salt. This wall contains an admixture of common salt. It was mixed at the rate of 2 lb of salt per hundredweight of soil. The soil was about average. The picture was taken after 2½ years exposure and is weathering very rapidly • Fig. 3 The check wall for the wall containing common salt. This check wall was built at the same time and from the same stock pile of soil as Fig. 2, except that it contains no salt. The soil is just average containing less than 50 per cent sand and will not stand as a bare wall without a sand admixture. Comparatively poor soils are used in tests of this kind because more definite results are obtained from definite failures • Fig. 4 A plated or veneered earth wall. This wall is plated on the outside surfaces (except the end) with the same soil stabilized with 15 per cent of portland cement by volume. The end of the wall shows the thickness of the plating. The picture was taken after only two years of exposure • Fig. 5 A 5 per cent admixture of portland cement in rammed earth. This wall was rammed from favorable soil with an admixture of 5 per cent of portland cement by volume. The surface was badly damaged by snow and ice during the winter 1940-41 for a distance of 8 to 10 in above the ground. The bottom 12 in only of one corner of the wall is shown

Plating the Walls. In order to reduce the cost of stabilizing earth walls, the plating of the surface only has been tried. A thickness of approximately 2 in for the plating layer has been used and three different stabilizing materials have been tried in the plating, namely, soil-cement, sawdust-cement concrete, and "Raylig". For the plating material the same soil was used as for the body of the wall, and these three materials were added as stabilizers. This plating process was not as tedious as was anticipated, although it requires a slightly longer time for building. The plating material containing the admixture was brought up to the wall in wheelbarrows and of course kept separate from the regular soil used. After each layer of soil was rammed and finished, the regular loose soil was shoveled into the form to be rammed for the next layer. But before ramming, a flat shovel was set down along the inner edge of the form as it would be used for "spading" fresh concrete. The point of the shovel was forced back from the form, pushing about two inches of the loose soil away from the form by prying out on the handle. This leaves the space back of the shovel ready for the loose plating material which is then shoveled in. The layer is then ready to ram. Our test walls were rammed by hand and it is quite probable that hand ramming would be better for plating work.

These plated walls were built in August 1940 and are still in the experimental stage, but so far as the process is concerned the prospects are very favorable. The only reason for plating or for using any admixture other than sand, for that matter, is when it is desired to leave a bare wall exposed in order to retain the identity of the material. The plating layer bonded with the wall without any difficulty, and there was just enough irregularity in thickness of the plating to give the wall a pleasing mottled surface. Of the three admixtures used only one promises to be practical and successful. That is the soil-cement plating in which a 15 per cent admixture of portland cement was used. The sawdust-cement concrete plating is standing up successfully so far, but it is difficult and expensive to make and probably has no advantage over the soil-cement. The "Raylig" stabilizer is a lignin product, a by-product of paper pulp manufacture. It has been used for stabilizing road bases to some extent on the northwestern coast. The lignin plating is beginning to show some signs of failing in less than two years. In an experimental floor project it is showing better promise. Raylig was used in the plating material at the rate of 0.6 gal of concentrated liquid per square yard of plating.

The cost of the soil-cement plating included the additional cost of the cement and the extra labor. Accurate record was made of each of these. The cement used measured two sacks per square of wall surface, which at 75c per sack, made the extra cost for cement $1.50. The extra time required for mixing and using the plating material was 1½ min per sq ft of surface, or 1 hr and 40 min per square (100 sq ft) of wall. Figuring labor at 40c per hr, the total cost of plating the outer surface only of a rammed earth wall for the average small single-story cottage having 13 squares of wall, would be $19.50 extra for portland cement and $8.76 extra for labor, or $28.26. If both sides of the wall were plated, the extra cost would be $56.52. It is possible that a 10 per cent admixture of cement for the plating material would have been sufficient. We will have the answer for this in another two or three years.

An Admixture of Asphalt Emulsion. Asphalt emulsion has been used successfully for stabilizing road bases for

several years. Soon after South Dakota station Bulletin 277 (first edition) was issued in 1933, the office of the American Bitumuls Company of San Francisco became interested in the possibility of using this material for stabilizing soil for building walls. At their request it was tried in rammed earth. An experimental weathering wall was built in the yard in which 1.2 gal of asphalt emulsion was added to each hundredweight of soil. The soil contained 37 per cent total sand by weight according to an analysis with the 200-mesh sieve, or 46 per cent by weight according to the hydrometer method of analysis. The wall has stood satisfactorily as a bare wall for 6 years although the soil used was not of high quality. The admixture increased both the moisture and weather resistance materially. However, the process of building with it was very tedious owing to the fact that the oil must be added to the soil when puddled or very wet. This made it unfit for use as rammed earth until it had been dried out, ground up, and readjusted for moisture.

Asphalt emulsion admixture lends itself readily to building with adobe brick. The American Bitumuls Co. developed this use for it during 1933 to 1936 and the manufacture of stabilized adobe, or "bitudobe", was begun on an extensive scale in southern California. The South Dakota station has done considerable work with this material both for use in walls and in floors, although nothing has been reported on it. Checks have been made against the recommended ratio of oil to "fines" (that portion of the soil which passes a sieve having 200 meshes per lineal inch) in the soil according to the specifications of the American Bitumuls Co., and found satisfactory. This ratio is 15 per cent by weight of oil to the fines in the soil. Using these specifications, wall bricks and floor blocks have been made and tested for both strength and weather resistance.

The strength of stabilized adobe was compared to the strength of plain or common adobe in a test made in the laboratory in 1940. Two different soils were used in the series. Sand was added to each of these soils in equal amounts, but the original amount of sand in the natural soil varied considerably. The soil used in the plain adobe and in the stabilized adobe in each series was taken from the same stock pile. Four test pieces were made and tested for each strength figure shown in the table. The test pieces were 8-in cylinders and 8 in high. As shown in Table 3 the favorable soil when used in plain adobe material, carried an average load of 158 lb per sq in. When stabilized with asphalt emulsion, this same soil carried an average load of 276 lb. (Had the test pieces been only 4 in high

TABLE 3. EFFECT OF ADDING ASPHALT EMULSION TO ADOBE BRICK UPON THEIR STRENGTH IN COMPRESSION

Kind of soil	No admixture-load in compression, lb per sq in	Admixture of asphalt, emulsion-optimum rate, load in compression, lb per sq in	Increased by admixture, %
Favorable soil, total sand content 60%	158	276	74
Unfavorable soil, total sand content 41%	217	198	–9

Test pieces 8 in high and each strength figure is the average of four like test pieces.

they would have carried nearly double this load.) This is a gain in strength of 74 per cent due to the admixture. Plain adobe made from the soil that is less favorable carried an average load of 217 lb per sq in, and when stabilized with the oil their strength was decreased by 9 per cent. This unfavorable soil was one that has been thoroughly tested, in the form of plain adobe, for weather resistance and found very poor. It is also rated as unfit for use as a rammed earth soil, being just below the border line in colloid rating. Since plain adobe has a strength in compression of approximately 43 per cent that of rammed earth, the ratio from Table 3 would give stabilized adobe a compressive strength about 75 per cent of that for rammed earth which is very good.

Stabilized adobe is also being studied for weather resistance and from the standpoint of comparative labor hours required in construction. Space will not permit a detailed discussion of these subjects in this paper. Weathering tests show that stabilized adobe is very resistant to moisture and other weather action. Present indications are that it will stand as a bare wall, i.e., without a protective covering and makes a rather attractive wall. As to the process of making the brick, this is a rather difficult job without special power equipment. It is definitely impractical to mix by hand, and while a concrete mixer can be used, a better brick will be made with machines similar to plaster mixers. The making of the brick can better be done in plants similar to our brick and tile plants, where the soil is processed, the sand as well as the oil weighed as it is added and the material mixed — all by machinery. Such plants are now operating in the Southwest.

SUMMARY

At least 80 per cent of all soil types, as they will be found on farms over the United States, will be satisfactory for use in rammed earth walls. Two-thirds of these could be used just as they are dug up providing the outside surface of the wall is to be protected with stucco or plaster. The other one-third will need at least a small amount of sand added, although they are to be plastered. A recommended admixture of sand will make a high percentage of these walls good enough to stand indefinitely as bare walls.

For farm buildings no admixtures other than sand are necessary. The sand will make a high quality soil and the wall may be left standing for a year or two. If it begins to roughen too much, it will just be right for stuccoing.

Cinders can be substituted for sand as an admixture to a low quality soil. Cinders reduced shrinkage and cracking of the wall in the same way as sand, and reduced the strength in the same proportion. They can be used up to one measure of cinders to one of soil if the wall is to be plastered.

Portland cement greatly increased the strength of rammed earth walls when the sand content of the soil was high, but only a small amount when the sand content was low. Five per cent of portland cement by volume was found insufficient for weather resistance. Possibly 10 per cent will prove satisfactory.

Snow and ice damaged earth walls containing portland cement admixtures (soil-cement walls) when left in contact with them. Allowance should be made for this in building the foundation well above grade in regions of snow fall. The damage to soil-cement walls was definitely greater than to plain rammed earth walls.

Fiber admixtures when well distributed through a soil increased the strength of the wall slightly, and it is not necessary to avoid the use of top soil nor to screen soils for this reason.

Plating or veneering rammed earth walls with the same soil, stabilized with a dependable admixture, has proven a satisfactory process. The dependability of the admixtures is still under test.

Asphalt emulsion has shown very satisfactory results as a stabilizing admixture for earth walls. It lends itself well to adobe type construction in which the oil can be mixed to puddled soils or mud.

NEWS

A.S.A.E. Fall Meeting at Chicago

THE Fall Meeting of the American Society of Agricultural Engineers will be held as usual at Chicago, December 7 to 9, at the LaSalle Hotel.

The Meetings Committee is now planning a program, the central theme of which will be gearing agricultural engineering to the war effort. The Committee plans to schedule only subjects that have a definite relation to the part which agricultural engineers are in position to play in connection with the efforts of the United Nations to win the war. Suggestions of subjects and speakers will be most welcome to the members of the Meetings Committee.

A.S.A.E. Meetings Calendar

September 28 and 29—North Atlantic Section, Belmont-Plaza Hotel, New York

December 7 to 9—Fall Meeting, LaSalle Hotel, Chicago

February . . . . —Southeast and Southwest Sections (joint meeting), New Orleans

June 21 to 23—Annual Meeting, Purdue University, Lafayette, Ind.

The North Atlantic Section "War Work Conference" at New York

AS announced last month the "War Work Conference" of the North Atlantic Section of the American Society of Agricultural Engineers will be held September 28 and 29 at the Belmont Plaza Hotel in New York City.

The following subjects have been scheduled, and the speakers named have accepted the Section's invitation to appear on the program:

Starting the program on Monday forenoon, September 28, Hon. M. Clifford Townsend, director of the USDA Office for Agricultural War Relations, will discuss what war requires of agricultural engineers.

Wheeler McMillen, editor of "Farm Journal and Farmer's Wife", will lead the discussion on the subject "Tools for Agriculture—Needs, Restrictions, Present Production", speaking from the standpoint of agriculture, while Oscar W. Meier, chief, agricultural machinery unit, Division of Civilian Supply, War Production Board, will discuss the subject from the WPB standpoint. Wallace Ashby of the USDA Office for Agricultural War Relations will lead discussion of the subject "How to Get Needed Building Materials and Farm Equipment", and A. H. Hemker of General Electric and Frank Hamlin of the Papec Machine will participate in the discussion of this subject. Arthur W. Turner educational advisor of International Harvester Company, will talk on the allocation of farm equipment.

The session for Monday afternoon, September 28, will deal entirely with the subject of repair and care of farm machinery and other equipment. C. N. Turner, extension agricultural engineer, Cornell University, will tell about an $80,000 machinery repair program in New York State.

W. C. Krueger, extension agricultural engineer for New Jersey, will tell about a one-man program of farm machinery repair in his state. J. R. Haswell, extension agricultural engineer, of Pennsylvania, will present the subject of farm equipment repair instruction by moving picture.

The subject "Vo-Ag Instructor Relationships with all Organizations Interested in Farm Machinery Care and Repair" will be discussed by D. C. Sprague of Pennsylvania State College. Participating in the discussion of the subject "Equipment Care and Repair Programs for Statewide Effectiveness", will be R. U. Blasingame of Penn State College, Roy W. Godley of Monongahela West Penn Public Service Company, B. P. Hess of Westinghouse, and a Miss Lerchen.

Following the foregoing program, the Section will hold its usual business meeting, and the regular Section dinner will be held in the evening with Wheeler McMillen as the speaker. His subject will be "Looking Ahead".

Following the dinner there will be round-table sessions, one devoted to structures and power machinery, of which A. A. Stone will be chairman, and the other on rural electrification, which will be presided over by F. L. Rimbach.

A. V. Krewatch, chairman of the North Atlantic Section, will open the Tuesday forenoon session, speaking on the subject "We Are Here". This will be followed by an address by R. B. Corbett, director of the Maryland Agricultural Experiment Station, speaking on "How Commodity Prices Govern What Agricultural Engineers Do". Wartime soil conservation work will be discussed by A. L. Patrick, assistant chief, Survey and Project Plans, USDA Soil Conservation Service, who will present a paper on "Wartime Soil Conservation Work", formal discussion of which will be led by Ray W. Carpenter of the University of Maryland. At this session also the subject of "Farm Buildings Blackout and Fire Prevention Requirements" will be discussed by G. H. Lentz of the USDA Forest Service, F. L. Rimback of the New England Power Association, and others. *(Continued on page 300)*

Completing what to A.S.A.E. members was a highly successful and gratifying year of service as the President of the Society, Geo. W. Kable is shown here — at the A.S.A.E. annual meeting in Milwaukee — (upper left) awarding the John Deere Medal to David P. Davies, (upper right) awarding the Cyrus Hall McCormick Medal to William D. James, (lower left) turning over the office of President of the Society to his successor, Harry B. Walker, and (lower right) awarding the Farm Equipment Institute Trophy to the representative (Richard Birney) of the A.S.A.E. Student Branch at Iowa State College, the 1942 winner.—Photos by courtesy of 1941-42 Meetings Chairman Arthur W. Turner and the International Harvester Company.

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers at the addresses indicated.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE IDAHO AG. EXP. STA. (Partly coop. U.S.D.A.) Bul. 239 (1941). Land reclamation and conservation research is reported upon by H. Beresford, J. P. Bonner, M. R. Kulp, J. C. Marr, J. L. Toevs, and W. Watson; field power and machinery by Beresford, T. A. Brindley, L. M. Christensen, E. N. Humphrey, and G. W. Woodbury; rapid developments in rural electrification by Beresford; and preparation of farm-building plans by Beresford and K. H. Parks.

FLOOD OF AUGUST 1935 IN THE MUSKINGUM RIVER BASIN, OHIO, *C. V. Youngquist and W. B. Langbein*. U. S. Geol. Survey, (Washington), Water-Supply Paper 869 (1941). The flood reported upon followed a fall of more than 8 in of rain over an area of 400 square miles during a 12-hr period on August 6-7, 1935, and resulted in the largest general summer flood known in this basin. This report presents in more detail than would be practical in the regular surface water-supply papers comprehensive factual information on the stage and discharge at 27 points in the basin and the flood-crest stage at 193 points, together with pertinent data on previous floods, records for which on the main river extend back with decreasing completeness to 1847.

This report contains sections on meteorologic and hydrologic conditions, by W. E. Smith; and meteorology of the storm, by A. K. Showalter.

ALL-WOOD GRAVEL CULTURE BENCH CONSTRUCTED OF TREATED LUMBER, *N. H. Alter*. Ohio Ag. Exp. Sta. (Wooster) Bimo. Bul. 211 (1941). Construction of a bench 4 by 53 ft is very briefly outlined. Photographs of various details, but no working drawings, are reproduced with the note. The bench was found to be easily assembled, and no leaks had occurred after 3 months' use, during which time satisfactory service for gravel culture was obtained. The author considers it doubtful, however, whether or not the design described can compete with others in cost of materials.

CONTROLLED-ATMOSPHERE STORAGE OF APPLES, *R. M. Smock and A. Van Doren*. New York (Cornell) Ag. Exp. Sta. (Ithaca) Bul. 762 (1941). The experiments reported upon covered several types of sealed-chamber construction, variations in carbon dioxide and oxygen percentages, effects of controlled-atmosphere storage on a number of horticultural varieties of apples, market life of the apples after removal from the storage chamber, effect on resistance to spoilage organisms, and other factors influencing the commercial practicability of the process.

A storage room for controlled-atmosphere storage should permit the leakage of not more than 10 per cent, preferably not more than 5 per cent, of the carbon dioxide content of its atmosphere during 24 hr. Details of wall-, floor-, and water-sealing construction are considered. The most suitable carbon dioxide concentration was found to be 5 per cent, with the oxygen concentration reduced to 2 per cent. The most suitable temperature appeared to be 40 F, giving a slight saving in refrigeration costs as compared with those of ordinary 32 F cold storage. Reduction of the carbon dioxide concentration to 5 per cent was effected by circulating the air through washing drums or scrubbers (which may be constructed from discarded oil drums) in which the air is drawn upward countercurrent to a spray of caustic soda solution, 1/3 lb per gal, falling through a series of baffle plates. Gas analysis apparatus for determining the carbon dioxide and oxygen contents of the storage-room atmosphere is a part of the necessary equipment. Scald required more precaution for its prevention in controlled-atmosphere storage than in ordinary cold storage because of the restricted air circulation, but was controlled in the less susceptible varieties by the mixing of from 1/4 to 1/3 lb of oiled paper with each bushel of fruit, the paper containing 15 per cent of tasteless, odorless mineral oil. For effective atmosphere control the storage room should be filled with fruit.

McIntosh, the variety found best suited to controlled-atmosphere storage, could be kept several months longer than in ordinary cold storage, and at a cost of approximately from 9½ to 10c per bu in addition to ordinary cold-storage costs and exclusive of operating labor. The market life of the apples after removal from storage was much longer after controlled-atmosphere storage than after ordinary cold storage. Brown core or core flush and internal browning, frequently occurring in apples stored at 32 F, can be avoided, in the McIntosh variety at least, in 40 F storage in a suitably controlled atmosphere; mold growth is retarded; and mice and rats cannot survive in such an atmosphere. By using both ordinary and controlled-atmosphere storage the operator can sell apples from harvest time through June or later. For the present, however, the only variety which seems to justify this practice is McIntosh. Other varieties which respond, but not so remarkably as McIntosh, are Northwestern Greening, Twenty Ounce, Delicious, Rome Beauty, and Northern Spy.

REPORT OF THE ADMINISTRATOR OF THE RURAL ELECTRIFICATION ADMINISTRATION (ST. LOUIS), 1940, *H. Slattery*. Among other topics taken up, this report deals with functions of the REA, the typical REA system, the electric cooperative, the work done by the REA, current fiscal status of REA borrowers, payments of interest and principal, economic trends, new developments in rural electrification law, and state legislative developments.

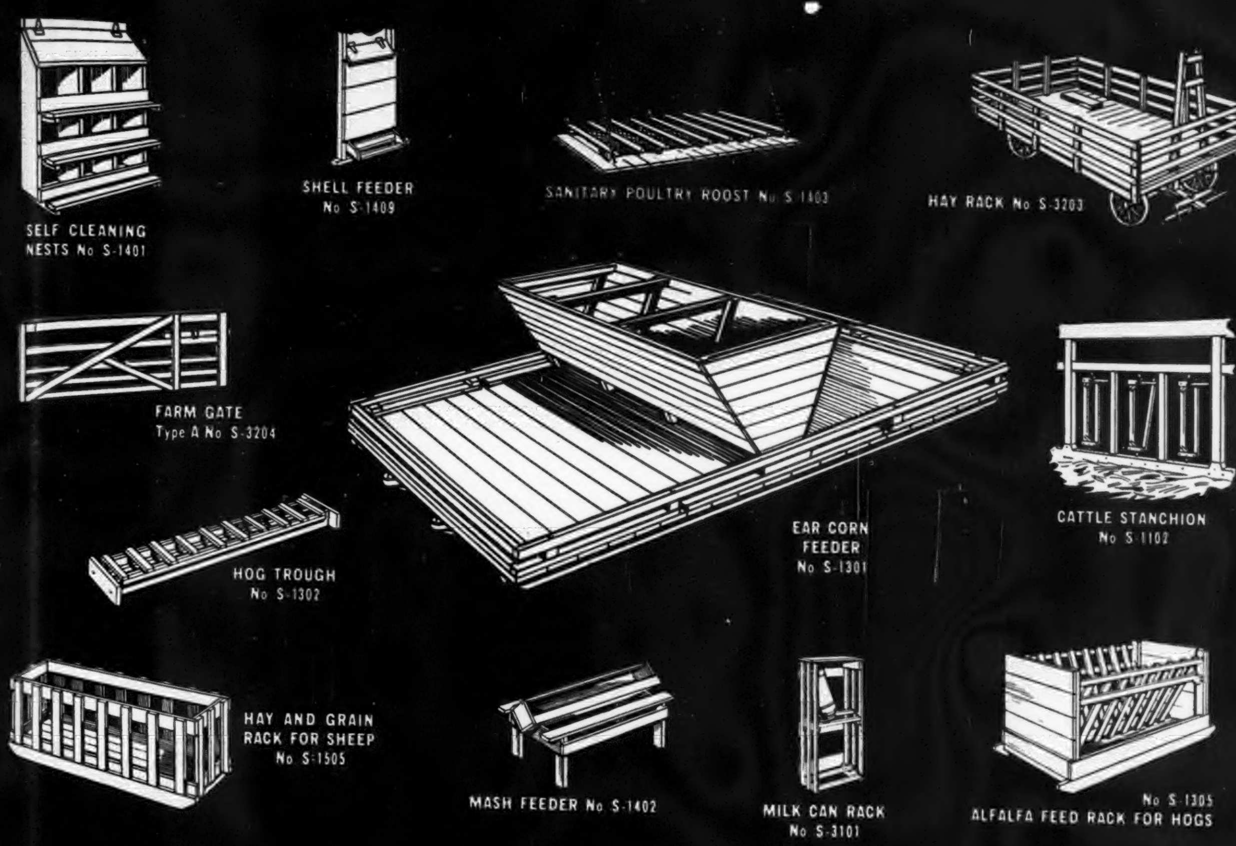
GRAIN STORAGE ON THE FARM, *T. E. Long and M. G. Cropsey*. (Coop. U.S.D.A.) North Dakota Ag. Exp. Sta. (Fargo), Bul. 302 (1941). This bulletin records the results of experiments with numerous types of bin construction and ventilation, weatherproofing, ratproofing, bracing against wind damage, etc. Horizontal ventilation flues were more effective than vertical flues, but no form of natural ventilation secured and maintained a moisture content low enough to prevent spoilage. Forced ventilation through a large air drum in the center of the wheat mass was effective when a centrifugal (silo blower) fan was used 1 hr each dry day to a total of 24 hr of operation. The wheat moisture content was reduced from 15.1 to 13.5 per cent in about 1 month, and the grain remained in good condition from August 1938 to April 1941.

The bulletin contains also a section on control of insects in stored grain by J. A. Munro.

CONTROL OF NOXIOUS WEEDS BY LIGHT BURNING AND HOW TO MAKE A BURNER, *G. W. Boyd and C. L. Corkins*. Univ. of Wyo. (Laramie), Ext. Cir. 75 (1941). The failure of chemical weed killers to provide satisfactory eradication, especially from soils either tight in physical structure or high in fertility and located in an arid climate, led the authors to design weed burners of three types (one hand-operated and two motor-driven), all producing a very hot spreading flame from such cheap fuels as used crankcase oil, refinery discard, light crude oils, and furnace oil. All of the burners were designed to preheat the fuel in a loop or coil of tubing placed in the flame. Construction of these burners is partially described, the necessary parts are listed with their approximate cost, photographic illustrations of burners and parts are included, and directions for weed eradication by this method are given. It is considered that in many instances burning by the methods indicated will be cheaper than the use of chemicals and will effect more complete eradication.

METHODS OF FIELD CURING HAY, *T. N. Jones, O. A. Leonard, and I. E. Hamblin*. Mississippi Ag. Exp. Sta. (State College), Tech. Bul. 27 (1941). Windrowing alfalfa hay aids natural transpiration, resulting in a greater moisture loss in a day. Photomicrographs show a reopening of the stomata following windrowing 2 hr after cutting. Double windrowing 2 or 3 hr after cutting gives the hay a better color, a larger percentage of leaves, and a lower moisture content at the end of the day. The leaves of alfalfa plants were found to aid greatly in lowering the moisture content of the entire plant. They were also found to contain from 60 to 90 per cent of the proteins and vitamins in hay. Light, increase in temperature, oxidative enzymes, copper, decrease in pH value, high relative humidity, and decrease in rate of drying were found to increase carotene loss from hays or hay plants.

Crushing large-stemmed hays, such as Johnson grass and soybeans, shortened curing time. Crushed hay could be stored with a carotene content higher than that of mowed hay. Crushed hay was as rich as mowed hay in proteins, sugars and dextrin, ether extract, and ash.



Needed farm equipment now available through the wide adaptability of lumber...

...despite the fact that the nation's tremendous demand for lumber has placed it on the list of critical materials and that the stocks of many dealers have been reduced.

Farmers can still get needed items of farm equipment for their fall and winter program, because of the wide adaptability of lumber—the interchangeability of sizes, species and grades.

Most items of farm equipment—self feeders for hogs, troughs, hoppers, alfalfa racks, self-cleaning nests, roosts, feed bunks, hayracks, gates, stanchions, can be made from smaller pieces of lumber stock—grades and species can be used interchangeably without seriously affecting the efficiency of the item. Accordingly, the present assortment of stocks in the majority of yards provides suitable lumber for the construction of fall and winter equipment and accessories.

Weyerhaeuser, working with agricultural engineers, has developed the 4-Square Farm Building Service. The latest addition to this service is a series of designs and plans for farm equipment and accessories that can be made from available lumber stocks. They bring to the farmer items that save feed, save labor and contribute to increased production. If you are interested in the new equipment section of 4-Square Farm Building Service, the book will be sent on request.

Lumber again demonstrates its value as the best and most economical material for farm construction. Buildings and equipment made of lumber can be easily and economically remodeled to serve a wide variety of farm needs.

4-SQUARE LUMBER

WEYERHAEUSER SALES COMPANY • ST. PAUL, MINN.

WEYERHAEUSER 4-SQUARE LUMBER

NEWS

(*Continued from page 296*)

Two papers on the subject of fire prevention and protection will feature the opening of the afternoon session of September 29, one of which will be "Spray Rigs for Fighting Farm Fires" by H. C. Stockdale, and the other on "Fire Prevention" (in motion pictures) by J. R. Haswell of Pennsylvania State College. John L. Burgan, director of rural development of the New York State Electric and Gas Corp., will present a paper at this session on "Rural Electrification Problems Awaiting Solution". W. D. Hemker of Westinghouse will discuss the subject of homemade equipment, in which other speakers will also participate. How to get important jobs done and to reach each farmer will be discussed by A.S.A.E. members adept at that sort of thing, including probably B. A. Jennings of Cornell University, R. H. Gist of West Virginia University, and others.

Other subjects and speakers will be added to the program before it is in final form, but those listed furnish evidence enough that the Section "War Work Conference" will not only live up to the name given to it, but should prove of outstanding interest and value to members both in the Section area and outside it who can arrange to attend what promises to be a very exceptional meeting.

Caster-Bean Sheller to Be Built

WORD has come from the agricultural engineering department of the University of Tennessee that the Commodity Credit Corporation has let a contract to build five of the castor bean shellers developed by A. H. Arnold, much like the machine described in AGRICULTURAL ENGINEERING for June. These shellers will be used for this year's crop. The CCC owns all the beans being grown for seed this year, on about 8000 acres, all of which will be used for seed next year. The most recent model of Mr. Arnold's machine has a capacity of 30 bushels per hour.

Representatives of the USDA Bureaus of Agricultural Chemistry and Engineering and Plant Industry examined eight different designs of castor bean shellers previous to their acceptance of Mr. Arnold's machine as being the most satisfactory and recommending it to the CCC.

Personals of A.S.A.E. Members

Edgar L. Barger has accepted appointment as professor of agricultural engineering at Iowa State College, where he will do teaching and research work in the field of mechanical farm equipment, succeeding E. G. McKibben, who recently resigned to become head of the agricultural engineering department at Michigan State College. Mr. Barger is a graduate of Kansas State College and also has a master's degree from that institution. After graduation he was employed by the Deere organization as service man and salesman, and also in advertising and sales promotion work as assistant to one of the company's branch managers. In 1930 he joined the agricultural engineering staff of Kansas State College as instructor later becoming associate professor. During the past year he has been head of the agricultual engineering department at the University of Arkansas.

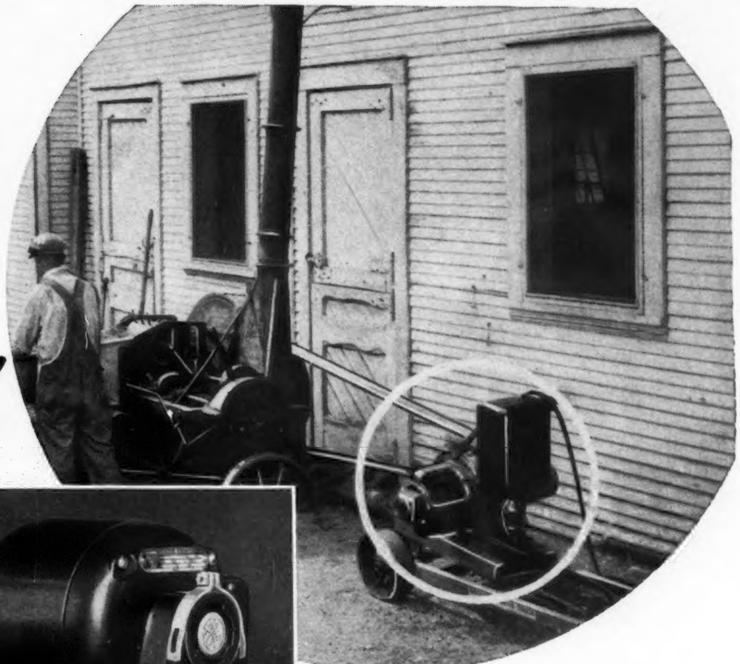
Edwin R. Kinnear, principal engineer, Office of Foreign Agricultural Relations, U. S. Department of Agriculture, will shortly leave for South America where he will be engaged in a managerial capacity with the Corporacion Ecuatoriana de Fomento, a semigovernment corporation which will carry out agricultural and other development projects in Ecuador in accordance with agreements made at the Rio Conference. He will be located at the American Embassy, Quito, Ecuador, and the assignment will probably be for the duration of the war.

Charles E. Peach is senior liaison engineer for the Vega Aircraft Corporation, Burbank, California, and in this position he serves as liaison between engineering and production on heavy bombers.

H. W. Riley, professor of agricultural engineering, is author of war emergency bulletin 25, "Save Labor at Haying Time", recently issued by Cornell University.

Reuben O. Schlegelmilch formerly instructor in agricultural engineering at Cornell University, is now employed as civilian radio engineer with the U. S. Army Signal Corps, with headquarters at the Signal Corps Radar Laboratory in New Jersey. Recently he was ordered to Research Enterprises, Ltd., in Canada as an engineering representative of the Signal Corps.

6 WAYS TO KEEP *"Wired Hands"* FIT



Hay chopping and blowing

AS THE farm-labor shortage grows increasingly acute, "wired hands" are more and more being substituted for hired hands to help produce the food that's going "to win the war and write the peace." On farms from coast to coast these electric motors are grinding feed, chopping hay, sawing wood, threshing grain, pumping water, and doing many other jobs; it is imperative that they be kept in tip-top operating condition.

These six steps to prevent trouble will help you avoid costly breakdowns, and the repairs that probably could not be completed for weeks.

1. Check motors frequently to keep bearings, windings, etc. free from dirt and grime.

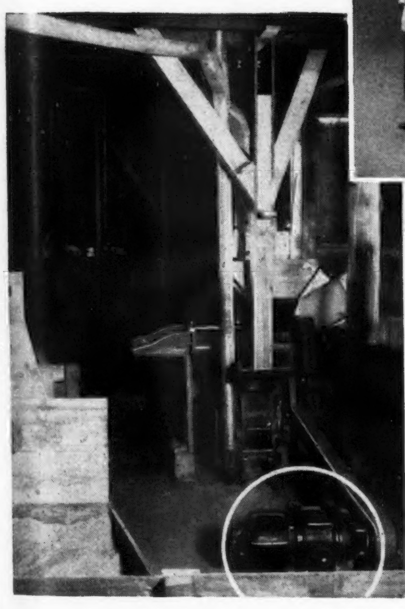
2. Keep bearings *properly* lubricated at all times, using light oil in babbitted sleeve bearings and light grease in ball bearings. Remember, too *much* lubricant is as dangerous as too little.

3. Remove motors from hazardous or extremely dusty locations (unless properly protected with enclosing shield).

4. Check belt alignment to avoid unnecessary bearing wear.

5. Provide positive overload protection. (This consists of a device that automatically shuts off a motor when too great a load is put on it.)

6. If motor is obviously not operating properly (smoke, scorched insulation, excessive noise, etc. are signs of probable breakdown), do *not* operate until it has been thoroughly checked and the cause removed.



Feed grinding and corn shelling

Your local electrical dealer will gladly work with you to keep your motors "healthy." In certain cases a short note to the Rural Electrification Section, General Electric, Schenectady, N. Y., will bring a solution to your motor problems. Mail the coupon today for your copy of a valuable, 16-page manual on the care of electric motors.

General Electric, Sec. 303-7
Schenectady, N. Y.

I want to keep my "wired hands" fit; send me a copy of "How to Care For Motors" (GEA-2856A).

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303-7C-155

GENERAL ELECTRIC

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Erwin J. H. Bentz, graduate trainee, Caterpillar Tractor Co., Peoria, Ill. (Mail) 509 North St.

John F. Eppes, Lieutenant, U. S. Army. (Mail) 347 Peabody St., Athens, Ga.

A. M. Hewlett, engineer, Honokaa Sugar Co., Haina, Hamakua, Hawaii, T. H.

Edwin J. Matthews, Pvt., Army Air Corps Technical School, University of Tennessee. (Mail) RR No. 1, Humboldt, Tenn.

Royal A. Miller, chief chemist, technical director, Illinois Farm Supply Co. (Mail) 1448 Park Ave., Pekin, Ill.

Edwin T. Mims, junior engineer, Federal Power Commission. (Mail) 1492 Ponce de Leon Ave., N.E., Atlanta, Ga.

K. W. South, district manager, L. H. Gilmer Co. (Mail) 3933 N. Murray Ave., Milwaukee, Wis.

TRANSFER OF GRADE

Leo E. Holman, agent (associate agricultural engineer), division of structures, BACE Laboratory, Iowa State College, Ames, Iowa. (Mail) 122 S. Riverside. (Junior Member to Member)

Student Branch News

National Student Council Officers, 1942-43

REPRESENTATIVE of the various Student Branches of the American Society of Agricultural Engineers which met at Milwaukee in June in connection with the Society's annual meeting, elected the following officers of the National Council of A.S.A.E. Student Branches for the ensuing school year: President, *Gus Boesch,* A. & M. College of Texas, Box 512, College Station; First Vice-President, *C. W. Bockhop,* Iowa State College, 2721 West, Ames; Second Vice-President, *E. D. Markwardt,* North Dakota Agricultural College, Fargo; Secretary, *Tom Durland,* South Dakota State College, Brookings.

TEXAS

By *Gus Boesch,* Scribe

THIS marks the first year in the history of the organization that the Texas A. and M. Student Branch of A.S.A.E. has had the opportunity of showing continuous activities throughout the year. Our new speed-up, year-round educational program has made this possible. In an effort to avail ourselves of this opportunity we are, as a group, planning one of the most extensive programs of activities that we have ever had.

Since the present summer semester began, we already have had five regular meetings at three of which student programs were presented. The second meeting of the year took the form of the annual welcoming picnic for the freshmen. This year's outing was a barbecue attended by some sixty A.S.A.E. members.

At the A.S.A.E. annual meeting this year, our Branch was represented by three delegates who reported on their activities on the first regular meeting night after their return. On this occasion it was our pleasure to have Joe Petty, a visiting agricultural engineering student from Oregon State College, in our midst. Joe was a delegate to the meeting from Oregon, and on his return trip he visited several days on the campus and made a short talk at our meeting on the activities in the field of agricultural engineering in Oregon.

At the first meeting in August one of our seniors gave an interesting discussion on why he took agricultural engineering. Another student spoke on the methods he has observed near his home in the control of wind erosion. Plans were also made for a watermelon feast for our next regular meeting.

An effort is being made to get the freshmen interested in the Branch, and throughout the year we plan to have programs that will be of special interest to them.

Our present merit award plan that was begun last year is proving invaluable as a stimulus to increased interest in Student Branch activities.

Definite plans are now being formulated for the annual Barnyard Frolic which we present each year as one of the functions to aid in raising funds for the Branch. Also we are setting out toward one of our goals to maintain a closer contact with each and every branch in the National Council of A.S.A.E. Student Branches.

We have high hopes and expectations for what this year may bring in the form of activities, and with this we give you Texas.

INSULATED FOR SAFETY

The Navy's Fire Fighters are "insulated" against blazing heat by an asbestos suit

As a result of modern naval developments, the navy's fire fighters are "insulated" against blazing heat.

And, by a modern Texaco development, Havoline Motor Oil, too, is "insulated" against heat — heat that causes some oils to break down and form harmful varnish — varnish that leads to ring-sticking and piston-drag, loss of power, waste of fuel.

And, in a sense, Havoline Motor Oil is "insulated" against cold—cold that makes some oils thicken and fail to give full lubrication protection, causing rapid wear, worry and costly repair bills.

The ability of Insulated Havoline Motor Oil to stand up at high temperatures and flow freely at low, makes it an ideal lubricant for farm tractors, trucks, automobiles, etc.

As an additional plus, Insulated Havoline is distilled. Harmful carbon-forming sludge and gum is removed. So the engine tends to stay clean and that means maximum power and economy from the fuel used.

Agricultural Engineers are urged to test Insulated Havoline and Texaco Motor Oils and learn for themselves the high qualities of these nationally distributed lubricants. Any queries will be gladly answered by experienced engineers. Phone the nearest of more than 2300 wholesale distributing points or write to The Texas Company, 135 East 42nd St., New York.

Insulated Havoline and Texaco Motor Oils and Texaco Diesel Oil cover completely the farmer's requirements for tractor, truck and automobile. For Diesel type tractors, Texaco Ursa-X★★ is recommended.

THE SEARCH NEVER ENDS FOR BETTER FUELS AND LUBRICANTS IN THE TEXACO LABORATORIES

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

DESIGN ENGINEER capable of original design of farm machinery and related lines, or a man capable of developing into a real design engineer, is wanted by a well-known manufacturer of farm machinery and other equipment. Persons interested are requested to write giving full particulars regarding technical training and experience and other pertinent information. PO-140

GRADUATE ASSISTANTSHIP open in the Pacific Northwest; may be used in the field of farm structures, farm machinery, farm power, rural electrification, or land development. This fellowship provides a stipend of $450 a year on a 9-month basis, requiring about one-third the student's time for teaching and laboratory assistance in elementary engineering subjects. It may be used over a 2-year period for graduate study leading to a master of science degree in agricultural engineering. Applicants should write Hobart Beresford, head, agricultural engineering department, University of Idaho, Moscow.

AGRICULTURAL ENGINEER wanted to fill position offering $2100 to $2500 per annum for duration of war. Combined teaching and research in agricultural engineering in the field of farm structures, graphic presentation, storage, refrigeration, and related subjects is covered by the opening. Applicants should submit with first letter complete personal record with recent photograph to Hobart Beresford, head, department of agricultural engineering, University of Idaho, Moscow.

TRACTOR SALES MANAGER wanted. State distributor for a leading make of farm tractor and implements wants an experienced executive who is qualified to head up sales and service activities. Must have proved sales record, aggressive sales ideas, and a knowledge of farming and its problems. Salary and bonus above average to right man. Write in confidence for application. PO-139

AGRICULTURAL ENGINEER wanted to fill position open in northeastern university due to absence of staff member in military service. Work involves approximately half extension and half resident instruction. Major concentration in farm structures and soil and water conservation. Salary up to $3000 for qualified person. PO-137

CIVILIAN ENGINEERS qualified for work in mining, metallurgical, electrical, radio, structural, sanitary, mechanical, and materials engineering, are needed by the federal government for appointment to many war agencies. Most of the positions pay from $2,600 to $3,800 a year. A few positions exist at higher salaries. Applications for these positions are obtainable at first and second-class post offices throughout the country and should be forwarded at once to the Civil Service Commission in Washington, D. C.

POSITIONS WANTED

AGRICULTURAL ENGINEER, with both bachelor's and master's degrees in chemical engineering, and with ten years' experience in the engineering phases of erosion control and drainage work, first as assistant engineer on CWA and PWA projects and more recently as junior agricultural engineer engaged in engineering design and layout for field work in soil conservation and erosion control, desires other employment due to liquidation of the Civilian Conservation Corps. Can furnish good references. PW-350

AGRICULTURAL ENGINEER with B. S. degree in agricultural engineering from Iowa State College. Has four years' experience as engineer with the Soil Conservation Service and five years' experience as state agricultural conservation engineer for the Agricultural Adjustment Administration. Experienced both in engineering and administration. Thirty-two years of age, married, and have family. References upon request. PW-348

AGRICULTURAL ENGINEER with B. S. degree in engineering and M. S. degree in agricultural engineering. Experienced in college teaching, experiment station, and extension work; also factory and construction work. Especially qualified for college agricultural engineering, manufacturing, defense, construction, or trade extension work. Age above draft. PW-346